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AMERICAN AND OTHER PATENTED INVENTIONS.

APRIL 1837.

Practical and Theoretical Mechanics.

Report on Strength of Materials for Steam Boilers.—CONTINUED.

In examining the eleventh and twelfth columns of Table XXIV., with a view to a relation which may afford a practical rule for calculating the strength of copper at any given temperature, it will be found, that with the exception of the three anomalous cases, Nos. 11. 14, and 17, of the table, they may be referred to a species of parabola, of which the ordinates representing the temperatures above 32°, have to the abscissas representing the diminutions of tenacity, a relation expressed by *the cube roots of the squares* of the latter quantities; or, in other words, that the *squares of the diminutions are as the cubes of the temperatures.**

* To determine whether any, and if any, what, single function of the temperature will at any point express the diminution of strength, as compared with that observed at other points, it was not deemed expedient to rely on a single comparison. The following method was, therefore, employed to obtain an expression corresponding with each of fourteen different points, compared with thirteen others. Putting t = any observed temperature above 32°; t' = any other temperature above the same; d = the diminution of tenacity by the former temperature, and d' = that by the latter: also x=the power of the temperature, according to which the diminution of tenacity varies, we have $t^x : t'^x :: d : d'$ whence $\frac{t'^x}{t^x} = \frac{d'}{d}$; from which we get $x = \frac{Log\ d' - Log\ d}{Log\ t' - Log\ t.}$ Thus at a temperature of 984° Fah., the tenacity was found by experiment to have been diminished .6691, its amount at 32° being 1.0000; and its diminution at 492° was .2133; hence by the above formula, $\frac{Log\ .6691 - Log\ .2133}{Log\ (984-32) - Log\ (492-32)} = 1.503.$

TABLE XXIV.

Experiments relative to the effects of temperature on the strength of rolled copper—made on the different bars subjected to trial during this investigation, the absolute strength being derived from a number of experiments on each bar, and the mean results of these furnishing for each separate bar a standard of comparison for the strength at high temperatures.

No. of the compar.	Temp. obs. at the time of fracture.	No. of exp. at each tem.	Str'gth in lbs. Avoir. per sq. inch at each tem.	No. of the bar on which the experi. was made.	Temp. at which expt. were made for compar.	No. of ex. on which the comp. cold str'gth is founded.	Strength at ordinary temp.	Ext. variation among the several experi.	Calculated strength at 32 degrees.	Elevation of temp. above 32 degrees.	Diminution of tenacity in parts of the str'gth at 32 deg.	Diminution of tenacity as calcula. from the law deduced.	Difference of calculated and observed results.	Original thickness of the plate.	Mean area of section at the points of fracture in each bar.	REMARKS.
1	32°	8	31830.5	2	62.°	7	31468	.032	31830.5	0.°	.0000	.0000	+.0000	$\frac{3}{16}$ inch	.143519	It is probable that the diff. .0073 between the strength at 32°, and that at 62° may be a little too great, but the nature of the law of decrease in strength will not be essentially affected by the excess.
2	62	7	31466.	2	62.	7	31468	.032	31830.5	30.	.0073	.0101	+.0028	$\frac{2}{16}$ do.	.143519	
3	122	4	33079.	3	62.	10	32428	.041	33671.	90.	.0175	.0182	+.0007	$\frac{1}{4}$ scant	.170358	
4	212	2	32187.	8	64.	8	33780	.048	34025.	180.	.0540	.0515	—.0025	$\frac{1}{4}$ full	.199017	As all the fractures except one at this temperature were in the hot bath, the strength is doubtless diminished by this temperature 212°.
5	302	2	30872.	8	64.	8	33780	.048	34025.	270.	.0926	.0945	+.0019	do.	.199017	
6	392	2	26154.	1	70.	8	30704	.028	30934.	360.	.1513	.1456	—.0057	$\frac{3}{16}$	.146147	
7	482	2	27081.	5	62.	11	33771	.026	34008.	450.	.2046	.2035	—.0011	$\frac{1}{4}$ full	.203877	
8	492	1	26752.	5	62.	11	33771	.026	34008.	460.	.2133	.2101	—.0032	do.	.203877	
9	545	1	25420.	6	62.75	7	33411	.022	33655.	513.	.2446	.2477	+.0031	do.	.186013	
10	561	1	25047.	6	62.75	7	33411	.022	33655.	529.	.2558	.2594	+.0036	do.	.186013	
11	602 ?	1	22302.	7	81.5	9	33005	.045	33473.	570. ?	.3307 ?	.2901	—.0406	do.	.184329	
12	692	1	21948.	4	75.25	6	33143	.019	33384.	660.	.3425	.3616	+.0190	$\frac{1}{4}$ scant	.173932	
13	801	1	18854.	6	62.75	7	33411	.022	33655.	769.	.4398	.4546	+.0148	$\frac{1}{4}$ full	.186013	
14	817 ?	1	16727.	7	81.5	9	33005	.045	33473.	785. ?	.5003 ?	.4689	—.0314	do.	.184329	
15	844	1	16768.	4	75.25	6	33143	.019	33304.	812.	.4944	.4932	—.0012	$\frac{1}{2}$ scant	.173932	
16	912	1	14789.	7	81.5	9	33005	.045	33473.	880.	.5581	.5565	—.0016	$\frac{1}{4}$ full	.184329	
17	992 ?	1	11091.	7	81.5	9	33005	.045	33473.	960. ?	.6686 ?	.6341	—.0345	do.	.184329	
18	1016	1	11054.	4	75.25	6	33143	.019	33384.	984.	.6691	.6588	—.0103	$\frac{1}{4}$ scant	.173932	
19	1032	1	10878.	4	75.25	6	33143	.019	33384.	1000.	.6741	.6741	+.0000	do.	.173932	

Note.—By an inspection of the above table it will be seen that at a temperature of about 550° Fah. copper loses one-fourth of its *tenacity at ordinary temperatures*; at 817° precisely one-half, and at 1000° two-thirds of the strength are taken away. By comparing the areas of the sections of fracture with the tenacity, it will be observed that the largest sections seem to afford the highest results; but as several bars, in which the difference is more observable, are from different sheets of copper, we may reasonably suppose that a real difference in the quality of the article may have existed. This table has furnished the basis of the curve of tenacity accompanying this part of the report.

By applying the law above stated* and assuming the greatest diminution observed, or that obtained at 1000° above the freezing point, as a true standard of comparison, we get the calculated results contained in the 13th column of the table, and a comparison of that with the 12th, furnishes the *differences* in column 14th. This last, compared with the 9th, shows that the greatest deviations even of the anomalous experiments already noticed, do not amount to so much as the actual irregularities sometimes found in the metal at common temperatures, for while the highest numbers in the 14th column are less than four and one-tenth per cent. of the total strength, several of those in the 9th amount to more than four and a half per cent. of the same sum.

The curve traced, (Plate IX.) represents the column of calculated results, and is continued to the opposite side of the figure to show to what point this law would lead as the temperature of no tenacity.† This

* The following table exhibits the mean results of the several sets of comparisons with the *temperature above* 32°, at which each experiment was made, and the diminution of strength corresponding, agreeably to the preceding note.

TABLE XXV.

No. of the comparison.	Temperature above 32 degrees.	Diminution from the ascertained strength at 32 degrees.	Mean value of x, by 13 comparisons at each point.	Difference of each from the mean value of all the trials.
1	90.°	.0175	1.536	+.036
2	180.	.0540	1.462	—.038
3	270.	.0926	1.518	+.018
4	360.	.1513	1.444	—.056
5	450.	.2046	1.489	—.011
6	460.	.2133	1.474	—.026
7	513.	.2446	1.447	—.053
8	529.	.2558	1.466	—.034
9	660.	.3425	1.474	—.026
10	769.	.4398	1.570	+.070
11	812.	.4944	1.565	+.065
12	880.	.5581	1.542	+.042
13	984.	.6691	1.557	+.057
14	1000.	.6741	1.458	—.042
		Mean of 14 means=1.500=x		

Hence $t^{1.5} : t'^{1.5} :: d : d'$, or $t^3 : t'^3 :: d^2 : d'^2$, which is the practical rule above given.

† The application of the law deduced from the research in the preceding note, to the purpose of getting the column of calculated diminutions, as well as to that of extending the curve to the limit of tenacity, requires but a transformation of the proportion $t^3 : t'^3 :: d^2 : d'^2$ into the equation $\left|\frac{t'}{t}\right|^3 = \left|\frac{d'}{d}\right|^2$, whence $\left|\frac{t'}{t}\right|^{\frac{3}{2}} = \frac{d'}{d}$, and $d' = d \times \left|\frac{t'}{t}\right|^{\frac{3}{2}}$ or $\frac{3}{2}(Log\ t' - Log\ t) + Log\ d = Log\ d'$. Thus to obtain the strength of copper at

is seen to be 1333 degrees Fah. which is 663 degrees lower than any determination of the melting point of copper hitherto made. It is well known that metals in general pass, in coming to the state of fusion, through a condition, in which though disintegration is nearly or quite complete, fluidity is not fully established; and in this granular state they, in some cases, continue through a considerable range of temperature. The melting points are those at which fluidity is clearly established. But notwithstanding this fact, and the very close accordance of the law above mentioned, with the observed diminutions of tenacity, we do not venture to assert that the theoretical law which might be derived from operating on copper absolutely pure, and of uniform tenacity throughout the specimen, would not give a form so varied as to change the parabolic curve into one possessing a *point of inflection*. An inspection of the figure as well as a reference to the table in the preceding note, will be found to favour the supposition that the rate of increase in temperature corresponding to a given decrease of tenacity, does in fact pass through a minimum near the point where one-half of the absolute tenacity is overcome. The right hand branch of the curve indicates the probable course *after inflection*.

Extensibility of Copper.

In producing the rupture of bars of copper it became evident that this metal undergoes during the mechanical strain to which it is subjected, a degree of elongation dependent, in some measure on the temperature to which it is raised. The mode of ascertaining this point, consisted in measuring after the trial of each bar had been completed, the united lengths of all its fragments. In reconstructing the bars for this purpose, care was taken to bring the corresponding portions into as close a contact as possible, and also to allow by estimation for any imperfection in the same from roughness of the fracture. A second mode was, to select from among the fragments of each bar one or more which retained the original inch-marks, and which had at the same time, been apparently strained to the full extent of its resistance, without actually parting. By this latter method of trial it was ascertained that the extensibility of all the 8 bars with the exception of Nos. 6 and 7, was nearly uniform, varying only between 40 and 44 per cent. of the original length. A section measured on No. 6, gave the length between two inch-marks only 1.25 inch, and on No. 7, 1.28. The trials on both these sections had been made at ordinary temperatures. When comparing the total lengths after fracture with the original length of each bar, we obtained as a general result, very nearly the same extension as when employing the several inch-marks as just stated. The mean elongation of the whole after 116

1232° Fah., we have 1232°—32°=1200°. ∴ *Log* 1200=3.0791821
Log 1000=3.

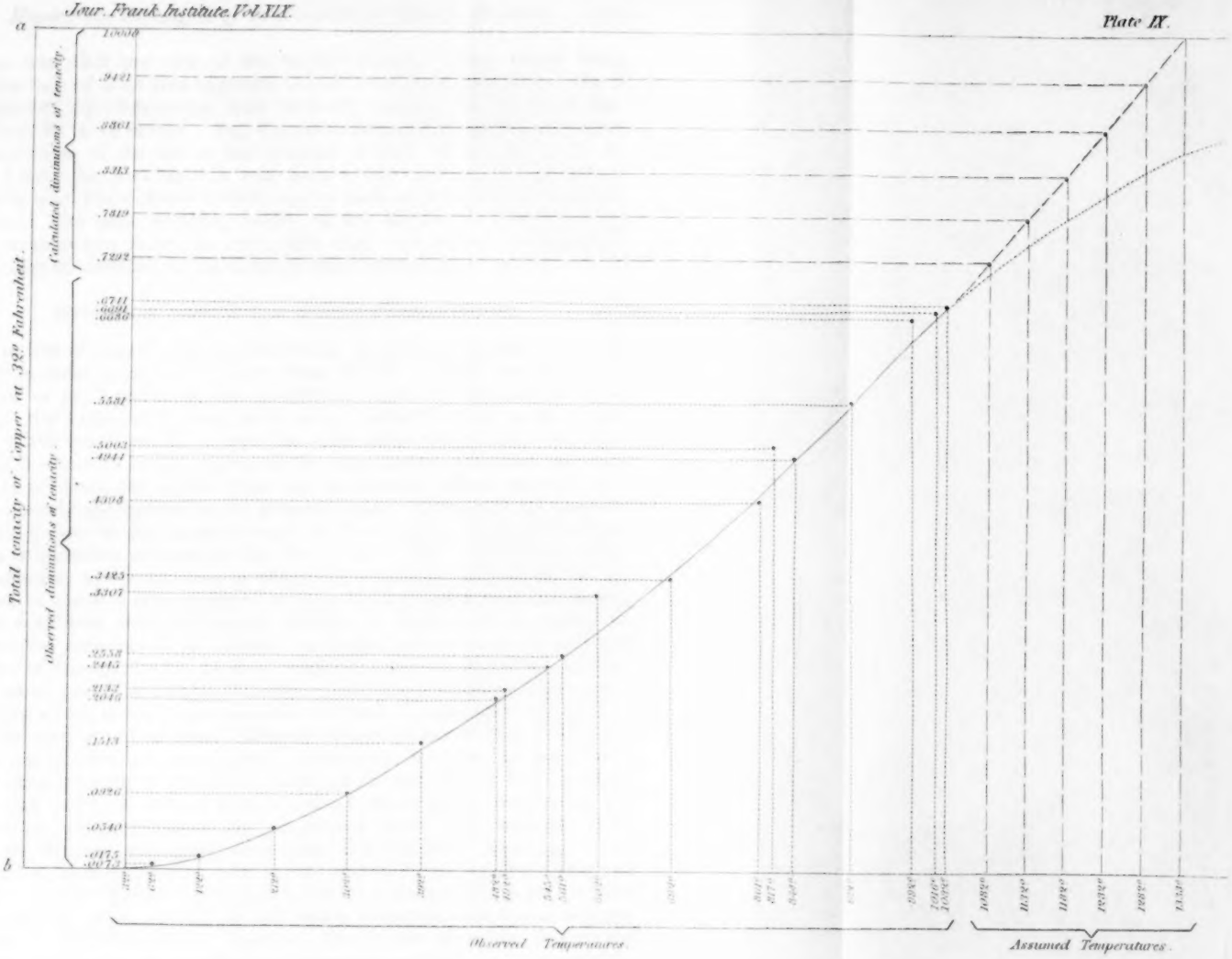
.0791821
3

2)2375463

.1187731
Add *Log* .6741=—1.8287243

Gives *Log* .8861=—1.9474964

Hence 1.000—.8861=.1139 is the *remaining strength*; or $11\frac{4}{10}$ per cent of the strength at 32°, is all that remains at 1232°, which is a visibly red heat in day light.



solutely uniform in size, amounts to not more than $\frac{1}{1750}$ or $\frac{1}{1666}$ part of the total strength. This portion is less than the irregularities in the structure of rolled iron, as may be shown by referring to tables LV. and LVII.

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Add *Log* .6741 = —1.8287243

Gives *Log* .8861 = —1.9474964

Hence 1.000—.8861=.1139 is the *remaining strength*; or $11\frac{4}{10}$ per cent of the strength at 32°, is all that remains at 1232°, which is a visibly red heat in day light.

fractures, was 43.5 per cent. of the original length. Other things being equal, the bars of least area appeared to have been most extensible. No. 2 was stretched, by 18 fractures, from 30 to 46¼ inches. No. 8, by 14 fractures, from 30 to 43 inches. But the circumstance of most importance is the temperature of the bar at the moment of trial. Thus on bar No. 7, (Table XXII.) the first fracture was made at 912° and the area of section afterwards was .744×.244=.181536 square inch, and the diminution from its original size only .002571, while at the thirteenth fracture, when the temperature was 81.5°, the area, after trial, was .550×.174=.095700, a diminution of .088316, or 34 times as much elongation as before.

Strength of boiler-iron at ordinary temperatures.

The results of experiments on boiler-iron, at ordinary temperatures, will be found included in thirty-two tables, from XXVI. to LVII., inclusive. On some few of the specimens, the strength of which is exhibited in these tables, all the experiments were made with a particular view to the irregularities of the metal, and at, or near the same temperature, while on other bars much diversity in the objects of the experiments prevailed, and consequently of these, only a few trials can be selected which may be considered entirely appropriate to the present topic. When making comparisons with a view to the mean strength of sheet iron, even from the same plate, it is necessary to consider that the question may be answered differently according to the direction in which the specimen was cut off; to the condition in which it was submitted to trial, whether rough from the shears, filed to a uniform size, and smooth surface, or filed away in notches to overcome the influence of the shears; or finally, according to the previous treatment of the specimens, whether subjected or not to annealing or other influences of heat after leaving the rolls. The tables furnish, under appropriate heads, the information necessary to answer, separately, the several questions arising out of these different aspects of the subject. With regard to the method of preparing the specimens, by reducing them to an uniform size throughout the whole extent of the bar, it may be remarked, that on the forty-one bars of iron, which in the course of this report, are described as having undergone that preparation, there were measured 1049 points, or sections, and there were made 517 fractures, showing, on an average, but little more than two inches between two adjacent points of fracture. It also appears that on only two of those bars (Nos. 220 A. and 224 B.) did the mean area of all the points measured, correspond exactly with that of all the sections of fracture. On 22 bars the mean area of the fractured parts is *less* than that of the measured sections, by an average of .000340 of a square inch, and on 17 bars the mean section of fracture is *greater* than the mean measured sections by an average amount of .000187. This proves, what might indeed have been anticipated, that the fractures would, in general, take place at the smaller sections, and as the mean area was about .175 sq. inch, it appears that the difference between the measured and the fractured sections, due solely to irregularities of filing, that is, between the condition of our specimens and that of others which should be absolutely uniform in size, amounts to not more than $\frac{105}{175000}$ or $\frac{1}{1666}$ part of the total strength. This portion is less than the irregularities in the structure of rolled iron, as may be shown by referring to tables LV. and LVII.

TABLE XXVI.

Experiments on iron bars No. 2, 4, 6 and 8. Manufactured by Messrs. Mason, Miltenberger & Co., at the Pennsylvania Iron Works, Pittsburg, from Juniata piled *iron. Nos. 2 and 4, cut lengthwise of the*

Number of the bar.	Direction of the slit.	Number of the experiment.	DATE.	Length before trial.	Breadth.	Thickness.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
			1832.				sq. inch.		lbs.		
2	Length.	1	June 13.	23.55	.890	.260	.231400	60°	479	14370	718
2	"	2	"		.660	.258	.170280	79.5	378	11340	567
4	Length.	1	"	23.6	.980	.256	.250880	65	415	12450	622
4	"	2	"	13.2	1.030	.260	.267800	65	460	13800	690
4	"	3	"		.990	.260	.257400	65	493	14790	739
6	Cross.	1	"	21.25	1.000	.220	.220000	65	444.5	13335	666
6	"	2	"	19.	1.058	.254	.268732	65	493	14790	739
6	"	3	"	10.4	1.054	.260	.274040	65	526	15780	789
8	Cross.	1	"	21.2	1.000	.252	.252000	65	443	13290	664

TABLE XXVI.

sheet, and 6 and 8 crosswise of the same. With the exception of experiment No. 2, the trials were all made at original sections. Specific gravity, 7.7169.

Effective strain.	Strength in pounds per square inch.	Weights producing temporary elongation.	Elasticity of the bar.	Length after trial.	Area of section after trial.	REMARKS.
lbs.		280—	"15			
		336—	"16			
13652	58997	392—	"19	23.8	.878×.240 =.210720	
		448—	"25			
		474—	"21.5			
		479—	Broke.			
10773	63266				.640×.230 =.147200	This fracture was made at a section deeply filed in the bar with square shoulders, perpendicular to the length of the bar.
11828	47146			23.85		
		224—	..35			
13110	48955	336—	..38	13.33	.996×.220 =.219120	
		448—	.16			
		460—	Broke.			
14051	54588				.958×.226 =.216508	
12669	57587			21.75		
14051	52286			19.1	1.048×.232 =.243136	
14991	54704				1.050×.234 =.245700	
		280—	.20			
		336—	.22			
12626	50103	392—	.15	21.4	.990×.228 =.225720	
		430—	.15			
		443—	Broke.			

TABLE XXVII.

Experiments on bar No. 3. Manufactured at the Pennsylvania Iron Works, by Messrs. Mason, Miltenberger, & Co., at Pittsburg, from Juniata piled iron—rolled into $\frac{1}{4}$ inch boiler-plate; cut with the shears

Marks.	Breadth.	Thickness.	Area before trial at the points measured.	DATE.	No. of the experiment.	Area of the section of fracture before trial.	Temperature. Fah.	Breaking weight in the scale.	Breaking weight multiplied by leverage.
				1834.					
1.	.757	.242	.183194	Jan. 13.	1	.183194	78°	346	10380
2.	.757	.242	.183194						
3.	.757	.243	.183951	"	2	.182979	78	354	10620
4.	.757	.243	.183951						
5.	.757	.243	.183951	Jan. 18.	3	.183194	520	356	10680
6.	.759	.241	.182919						
7.	.760	.241	.183160	"	4	.184437	572	371	11130
8.	.758	.243	.184194						
9.	.756	.243	.183708	"	5	.183951	574	379	11370
10.	.759	.242	.183678						
11.	.656	.242	.182952	"	6	.185074	576	399	11970
12.	.754	.242	.182468						
13.	.757	.244	.184708	"	7	.183951	76	417	12510
14.	.757	.243	.183951						
15.	.757	.242	.183194	"	8	.183160	76	417	12510
16.	.757	.243	.183951						
17.	.759	.244	.185196	"	9	.183194	76	417	12510
18.	.758	.244	.184952						
19.	.759	.243	.184337	"	10	.183708	76	417	12510
20.	.758	.243	.184194						
20.5	.753	.243	.182979	"	11	.183043	76	440	13200
Mean of 14=.183751				"	12	.183951	76	440	13200
Maximum .185196				"	Mean of 12	.183653			
Minimum .182468									
Mean of the two .183832									
Diff. of the two .002628									

TABLE XXVII.

lengthwise of the sheet, and reduced by filing through 20.5 *inches of its length. Specific gravity* 7.7169.

Friction.	Effective strain.	Strength in lbs. per square inch.	Point fractured.	REMARKS.
519	9861	53828	No. 1.	
531	10089	55137	" 20½.	
534	10146	55389	" 2.	Part in melted tin from 9 to 13—the fracture is 7 inches from the melted metal.
556	10574	57331	" 19.	Six inches from the heated part.
568	10802	58722	" 3.	Six inches from the heated part.
598	11372	61445	" 17½.	Four and a half inches from the tin.
625	11885	64609	" 16.	
625	11885	64889	" 7.	
625	11885	64876	" 15.	
625	11885	64695	" 9.	
660	12140	68509	" 10⅞.	
660	12540	68170	" 14.	The mean area of the sections of fracture is .000098 sq. in. *less* than the mean area of the measured sections.

TABLE XXVIII.

Experiments on bars Nos. **9, 10,** *and* **11.** *Manufactured by Henry S. Spang & Son, at the Ætna rolling mill, near Pittsburg, Pa. The blooms made by Henry S. Spang, Huntingdon county, Pa. Hammered into slabs, and rolled into sheets. These bars, cut with the shears lengthwise of the sheet. The fractures, made either at original*

No. of the bar.	Direction of the cut.	No. of the Exp't.	DATE.	Length before trial.	Breadth before trial.	Thickness before trial.	Area before trial.	Temperature. Fah.	Breaking weight in the scale.	Breaking weight multiplied by leverage.	Friction.
9	Length.	1	1832. Sep. 19,	23.7	1.000	.202	.202000	65.°	373.5	11205	+560*
9	"	2	"		.966	.210	.202860	65.	417.	12510	—625
9	"	3	"		1.000	.210	.210000	65.	427.	12810	—640
9	"	4	Sep. 26,		.691	.212	.146280	568.	394.	11820	—591
9	"	5	Oct. 3,		.596	.212	.126352	61.	289.	8670	—433
9	"	6	"		.734	.212	.155608	80.	378.	11340	—567
10	Length.	1	1832. Sep. 19,		.712	.204	.145248	575.	327.	9810	—490
10	"	2	"		.643	.204	.131172	100.	333.	9990	—499
10	"	3	Sep. 22,		.693	.204	.141372	73.	320.	9600	—480
10	"	4	"		.650	.201	.130650	574.	294.	8820	—441
10	"	5	"		.661	.208	.137488	571.	358.	10740	—537
11	Length.	1	1832. June 7.	23.6	1.000	.204	.204000	70.75	272.	8160	+408
11	"	2	"	18.6	.972	.201	.195372	70.75	348.	10440	—522
11	"	3	"		.954	.205	.195570	70.75	381.	11430	—571

TABLE XXVIII.

sections as the bar came from the shears, or at sections deeply filed on the edges with a semicylindrical file making two notches directly opposite to each other; between the deepest parts of which the measurements were taken. Specific gravity 7.7874.

Effective strain.	Strength in lbs. per square inch.	Length after fracture.	Area of the section after fracture.	REMARKS.
11765	58191	24.5	.932×.190 =.177080	* The bar was broken with a rising motion of the lever, that is, by drawing up the weight with the screw—hence the *friction* (.05 of the weight) is to be *added*.
11885	58587			Broke at an original section near the wedges.
12170	57952			Broke at an original section near the filed section, which now bore 59.462 lbs. per sq. in., its area being .997×.210=.205170.
11229	76763			This experiment made with great care, continued one and a half hours.
8237	65191			
10773	69232			
9320	64166			Broke suddenly at the filed section.
9491	72355			The temperature recorded is approximate only, being derived from the heated heads, still warm from the last experiment.
9120	64511			
8379	64133			
10203	74210			
8569	42000	23.9		Fracture made with a rising motion of the lever, the friction is therefore to be added to the weight.
9818	50253		.967×.167 =.161489	A section had been filed, the area of which was .193570, but the bar did not break at that point.
10859	55529		.870×.161 =.140070	Broke at the filed section above mentioned.

TABLE XXIX.

Experiments on bar No. 14, *cut from a sheet of boiler iron by a* cross *section. Manufactured at the Ætna Rolling Mill, near Pittsburg, by Henry S. Spang & Son from blooms made by Henry S. Spang, in*

Marks.	Breadth.	Thickness.	Area of section at the points measured.	DATE.	No. of experiment.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.
0	.698	.221	.154258					
1	.700	.210	.147000					
2	.700	.214	.149800	1833.				
3	.695	.215	.149425	Oct. 25	1	.157854	77	291
4	.697	.218	.151946					
5	.697	.216	.150552					
6	.697	.212	.147764					
7	.697	.215	.149855	"	2	.155400	732	291
8	.696	.221	.153816					
9	.695	.221	.153595					
10	.695	.221	.153595					
11	.697	.221	.154037	"	3	.148287	552	291
12	.697	.228	.158916					
13	.700	.225	.157400					
14	.700	.221	.154700					
15	.701	.224	.157024	Oct. 30.	4	.160310	59	343
16	.700	.224	.156800					
17	.700	.222	.155400					
18	.700	.228	.159600					
19	.700	.232	.162400	"	5	.155400	59	322
20	.700	.232	.162400					
21	.697	.230	.160310					
22	.692	.229	.158468					
	Mean of 23 =		.154746	Nov. 7.	6	.150055	63	331
	Maximum		.162400					
	Minimum		.147000	"	7	.156476	64	340
	Mean of the two		.154700					
	Difference		.015400	"	8	.153705	64	342
					Mean of 8=	.154686		

TABLE XXIX.

{ *Huntingdon County, Pa.* Hammered *into slabs, and* rolled *into sheets.*
Specific gravity of the specimen from which it was cut, 7.7874.

Breaking weight × leverage.	Friction.	Effective strain.	Breaking weight in lbs. per square inch.	Point of fracture.	REMARKS.
8730	436	8294	52542	No. 12¾	Part in tin from 15½ to 18.
8730	436	8294	53378	" 17	
8730	436	8294	55932	" 6¼	
10290	514	9776	60982	" 21	
9660	483	9177	59054	" 13¾	
9930	496	9434	62870	" 3¼	
10200	510	9690	61926	" 11½	
10260	513	9747	63413	" 8½	The point of fracture had been crushed in the wedges in a former experiment. The mean of the 23 measurements taken before trial is *greater* than the mean of the 8 points of fracture by .000060 square inch.

TABLE XXX.

Experiments on bars Nos. 17, 18. 21, 22 *and* 23. *Manufactured by Messrs. H. S. Spang & Son, at the into slabs, and rolled. Specific gravity,* 7.77.

No. of the bar.	Direction of the slitting.	No. of the exp't.	DATE.	Length before trial.	Breadth.	Thickness.	Area of section before trial.	Temp. Fah.	Br. weight in the scale.	Br. weight × leverage.	Friction.	Effective strain.	Strength in lbs. per sq. inch.
			1832.										
17	Cross.	1	April 4,	23.9	1.024	.260	.266240	59.°	374	11220	+561	11781	44249
18	Cross.	2	"		.986	.264	.260304	59.	415	12450	+622	13072	50218
21	L'gth.	3	"	24.1	.984	.252	.247968	69.	336	10080	504	9576	38618
21	"	4	"	17.4	.986	.260	.256360	69.	356	10680	534	10146	39578
22	L'gth.	5	Sept. 29.		.703	.249	.175047	565.	350	10500	525	9975	56984
22	"	6	Oct. 3.		.720	.257	.185040	581.	430	12900	645	12255	66229
22	"	7	"		.626	.255	.159630	90.	260	7980	399	7581	47491
22	"	8	Oct. 10.		.683	.255	.174165	68.25	354	10620	531	10089	57928
22	"	9	"		.687	.257	.176559	515.	383	11490	574	10916	61826
22	"	10	Oct. 25.		.627	.257	.161139	56.5	315	9450	472	8978	55716
22	"	11	Oct. 31.		.675	.260	.175500	90.	347	10410	520	9890	56353
23	L'gth.	12	Oct. 31.	24.3	1.004	.260	.261040	69.	392	11760	588	11172	42798
23	"	13	"	21.1	1.020	.260	.265200	69.	426	12780	639	12141	45780
23	"	14	Nov. 18.		.736	.264	.194304	394.5	462	13860	693	13167	67765
23	"	15	"		.775	.252	.195300	87.5	452	13560	678	12882	65960
23	"	16	"		.713	.256	.182528	87.5	380	11400	570	10830	59333

TABLE XXX.

Ætna Works, near Pittsburg, from blooms made by H. S. Spang, of Huntingdon county. Hammered

Wt. producing temporary elongation.	Elasticity of the bar.	Length after fracture.	Area of the section after fracture.	REMARKS.
259	23.			
280	22.			
294	14.			
326	17.5			
336	21.	24.1		Broke with a rising motion which makes the friction conspire with the weight in producing the fracture. Hence the sign + in the column of friction.
350	24.			
364	31.5			
371	27.			
374	Broke.			
392	32.			
403	37.5			
412	39.			
415	26.		.980×.256	After the bar had been for some time strained with 415 lbs., the process was arrested for the purpose of trying the elasticity under less weight. The remaining strength, it appears, was 277 lbs.
415	B. p'tly off.		=.250880	$=\frac{277}{415}=\frac{9}{14}$ nearly; or about 64 per cent. of the original strength.
Elas. af. par. fi.				
130—	14.			
214—	18.5			
277	Fin. br. off.			
224—	17.	24.4	.966×.236 =.227976	The bar broke at once, on applying by mistake, 336 lbs. It is probable that this point was extremely weak'd by the shears, or by straightening it, after being cut.
280	25.			
321	26.	17.8	.970×.240 =.232800	Broke with a slow and regular application of weights.
336	28.			
356	Broke.			
				Do. This and the 6 following experiments were made on deeply filed sections.
				The fracture took place soon after adding the weight recorded. The experiment is, however, considered a fair one.
280	21.			
364	31.	24.4	1.004×.240 =.240960	A flaw appeared in the edge, but before the final separation 8 or 9 pounds more *were necessary*.—Original section.
393	Broke.			
280	29.			
364	22. ?	21.45	.996×.254 =.252984	Broke at a section not filed.
413	57.			
426	Broke.			
			.660×.216 =.142560	Filed section.
				Do.
				Do.

TABLE XXXI.

Experiments on bar No. 16 *boiler plate. Manufactured by Henry S. Spang & Son, at the Ætna Rolling Mill, near Pittsburg, Penn. The blooms made by Henry S. Spang, Huntingdon County, Pa. Ham-*

Marks.	Breadth before trial.	Thickness before trial.	Area of sections at the points measured.		No. of the Experiment.	DATE.	Area of the section of fracture.	Temperature Fahrenheit.	Breaking weight in the scale.	Breaking weight & leverage.
						1833.				
0	.750	.212	.159000		1	Oct. 19.	.139999	57.5°	263	7890
1	.747	.212	.158364							
2	.738	.210	.154980							
3	.742	.202	.149884		2	"	.151500	636	266	7980
4	.744	.202	.150288							
5	.750	.202	.151500							
6	.750	.202	.151500							
7	.749	.206	.154294		3	"	.154294	58	308	9240
8	.749	.203	.152047							
9	.747	.200	.149400		4	"	.147159	58	323	9690
10	.747	.197	.147159							
11	.747	.197	.147159		5	"	.150086	60	323	9690
12	.747	.189	.141183							
13	.746	.188	.140248							
14	.746	.187	.139502							
15	.750	.184	.138000		6	Oct. 24.	.137250	766	264	7920
16	.750	.184	.138000							
17	.750	.183	.137250							
18	.750	.183	.137250							
19	.751	.190	.142690							
20	.750	.191	.143250							
21	.750	.194	.145500							
22	.750	.188	.141000		7	Oct. 26.	.137250	644	264	7920
Mean of 23			.146497	The mean area of the 23 measured sections is .001697 sq. inch *greater* than that of the 11 sections of fracture.						
Maximum			.159000		8	"	.153281	72	338	10140
Minimum			.137250		9	"	.138000	72	322	9660
Mn. of the 2			.148125		10	"	.140877	72	304	9120
Diff. of the 2			.021805		11	"	.143110	72	306	9180
						Mean	.144800			
Experiments on bar No. 13 from the same specimen as the above. Length before trial 23.45.				Br. .884 .880	Th. .212 .212		.187408 .186560	65 65	332 336	9960 10080
Experiment on No. 15 of which the length was 24 inches.				.954	.212		.202248	65	356	10680

TABLE XXXI.

mered into slabs and then rolled into sheets. This bar was cut across *the direction in which the sheet passed the rolls; reduced by filing, and gauged at every inch, from* 0 *to* 22. *Specific gravity,* 7.7874.

Friction.	Effective strain.	Strength in pounds per square inch.	Wts. producing temporary elongation.	Elasticity.	Point fractured.	REMARKS.
394	7496	53543			No. 13½	
399	7581	50039			" 5⅔	Part in tin from 4 to 7. Fracture in the melted metal. In taking the temp., with the pyrometer, a few grains of tin accompanied the standard piece, but were afterwards taken out and found to weigh 24°, which being added to the observed deficiency gave 400 + 212 + 24 = 636°.
462	8778	56887			" 7	
484	9206	62558			" 10	
484	9206	61338			" 3½	Broke with the same weight as the preceding.
396	7521	54819			" 17¼	The part in melted metal from 16 1-2 to 19 1-2; after having tried the temp. as the bar was stretching, and obviously ready to break, removed the furnace and took out the tin, suspended the weight on it for two days, after which the breadth was taken at the narrowest part, and found to be .691 inch instead of .750 as at first.
396	7524	54819			" 17¾	Same part in as above. The heating was now repeated, but instead of allowing the furnace to continue fixed, it was lowered when the bar began to stretch until the motion was retarded and then again brought up till it was renewed, and so on two or three times, to avoid heating the standard piece higher than was absolutely necessary to break the bar.
507	9633	63852			" 2½	
183	9177	66500			" 16	
456	8664	61500			" 18⅞	Had been near the hottest part.
159	8721	60939			" 19¾	Blue from heat.
498	9462	50488	280 310	0°..32′ 0 ..29	Areas after fracture. .860×.194=.166840	Broke at a part annealed. The length after fracture was 23.8, showing very little extension.
504	9576	51329	332	0 ..31	.862×.18=.15516	Broke in two places 2 inches apart.
534	10146	50166	280 329	0°53′ 0 40	.946×.190=.179740	Broke at the filed section, but not at the smallest part, showing an evident want of uniformity in strength. Length after fracture, 24.5.

TABLE XXXII.

Experiments on bar No. 19. *Manufactured by Henry S. Spang & Son, from blooms made by Henry S. Spang, Huntingdon county, Pa. Hammered into slabs, filed and rolled into plate. This strip was cut*

Marks.	Breadth.	Thickness.	Area before trial.	DATE.	No. of the experim't.	Area of the section of fracture.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.
1	.760	.250	.190000	1833.					
2	.754	.251	.189254	June 22,	1	.189128	576°	326	9780
3	.757	.255	.193035						
4	.754	.252	.190008						
5	.756	.248	.187488						
6	.755	.249	.187995						
7	.754	.251	.189254	"	2	.190000	570	378	11340
8	.756	.250	.189000						
9	.753	.252	.189756						
10	.755	.250	.188750						
11	.754	.251	.189254						
12	.754	.253	.190762						
13	.756	.252	.190512	June 29,	3	.188750	77	290	8700
14	.758	.253	.191774						
15	.758	.252	.191016						
16	.756	.251	.189756						
17	.757	.246	.186222	"	4	.189567	77	296	8880
18	.756	.245	.185220						
19	.757	.248	.187736	"	5	.187995	77	305	9150
20	.753	.246	.185238						
21	.773	.244	.188612	"	6	.187488	77	315	9450
Mean of 21 =			.189078	"	7	.189254	77	319	9570
Maximum			.193035	"	8	.190595	72	234	7020
Minimum			.185220						
				"	9	.185470	72	267	8010
Mean of the 2 =			.190627						
Diff. of the 2 =			.007815	"	10	.186478	72	291	8730
				"	11	.186487	73	314	9420
				"	12	.191774	73	290	8700
				"	13	.187989	73	291	8730
					Mean of 13 =	.188536			

TABLE XXXII.

with the shears in a direction crosswise of the sheet, reduced to a nearly uniform size by filing. Specific gravity 7.7764.

Friction.	Effective strain.	Strength in lbs. per square inch.	Point fractured.	REMARKS.
489	9291	49125	No. 10¾	In tin from 9½ to 13. The bar, on being strained, manifested an unequal extensibility in the three different laminæ of which it was composed.
567	10773	56700	" 1	Part now in tin is from 2½ to 6½, the length of the part embraced between the two heads is 8 inches. On raising the temperature from 180° to 510°, under a strain of 326 lbs. the index fell 1° 05′ on the arc.
435	8265	43788	" 10	Broke at a part previously griped by the wedges. This and the subsequent trials were on annealed portions.
444	8436	44501	" 8¾	
457	8693	46187	" 6	
472	8978	47886	" 5	
478	9092	48041	" 2	
351	6669	34990	" 12⅔	
400	7610	41031	" 17½	
436	8294	44477	" 18½	
471	8949	47987	" 19½	
435	8265	43098	" 14	
436	8294	44120	" 16½	The mean area of fracture is *less* by .000542 square inch than the mean area of the measured sections.

TABLE XXXIII.

Experiments on bars No. 25, 27, 30, 32, 35, 37, 39 and 41. Manufactured at the Sligo Iron Works, Pittsburg, by Barnet Shorb, from Juniata blooms, piled and rolled into boiler-plate. Nos. 25 and 27 were cut lengthwise from a quarter-inch sheet, and Nos. 30 and 32, crosswise

No. of the bar.	Direction of the slit.	DATE.	No. of the experim't.	Length before trial.	Breadth.	Thickness.	Area of the section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
25	Length,		1	24.1	1.000	.238	.238000	69.°	370.	11100	555
25	"		2	19.2	1.022	.240	.245280	69.	378.	11340	567
25	"		3	17.4	1.072	.236	.252992	65.	410.	12300	615
25	"		4		1.093	.234	.255762	65.	413.	12390	619
25	"		5		1.080	.232	.250560	65.	416.	12480	624
25	"		6		1.107	.232	.256824	65.	439.	13170	658
27	Length,		7	24.2	1.012	.204	.206448	62.5	403.	12090	604
35	Length,		8	23.15	1.092	.214	.233688	59.	354.5	10635	531
37	Length,	1832. May 15,	9	22.	.480	.220	.105600	73.5	171.	5130	256
30	Cross,		10	22.9	.874	.240	.209760	62.5	329.	9870	493
32	Cross,		11	23.	1.060	.234	.248040	60.	410.	12300	+647
39	Cross,		12	23.5	1.040	.214	.222560	73.5	317.	9510	475
41	Cross,		13	23.35	.994	.222	.220668	73.5	292.	8760	438

TABLE XXXIII.

from the same. Nos. 35 *and* 37 *were taken lengthwise, from a three-sixteenth inch-sheet; 39 and 41, crosswise from the same. The specific gravity of the first four was* 7.764, *and of the other four,* 7.7954.

Effective strain.	Strength in lbs. per square inch.	Weight producing temporary elongation.	Elasticity of the bar.	Length after trial.	Area of section after fracture.	REMARKS.
10545	44307	224 361 370	39. 28.5 Broke.	24.4	.980×.210 =.205800	Broke at the smallest section.
10773	43921			19.9	.978×.214 =.209292	Broke at an unfiled section
11685	46186				1.014×.195 =.197730	Broke at an original section. A section had been filed to the area of 1.044×.234=.244296.
11771	46023				1.066×.203 =.216398	
11856	47319				1.060×.189 =.200340	
12512	48718				1.103×.196 =.216188	
11486	55636	224 336 392 403	35. 38. 53. Broke.	24.4	.986×.196 =.193256	Br. at an original section.
10104	43237			23.2	1.088×.204 =.221952	Br. at an original section —no filing on this bar.
4874	46155	112 162 171	33. 43. Broke.	22.1	.440×.202 =.088880	A narrow strip. Broke at an original section.
9377	44703			23.1		
12947	52197	112 168 224 280 336 392 410	10.5 10. 12. 13.5 16. 17. Broke.	23.1	1.044×.216 =.225504	Br. with a rising motion of the lever, that is, while taking up the weight by the force of the screw—the friction is therefore positive & one-nineteenth of the wt.
9035	40595	224 315 317	20. 31. Broke.	23.65	1.020×.204 =.208080	The lamellated structure was exhibited by the different port'ns in the thickness, having separated for more than 4 inches near the frac.
8322	37713	224 282 292	45. 27.5 Broke.	23.85	.948×.216 =.204768	This bar had been cut from the same specimen as the preceding and broke in the same manner, viz. with a flaky separation of the laminæ.

TABLE XXXIV.

Experiments on bars No. 42, 43, 44, 46 and 48. Manufactured by H. Blake & Co., Pittsburg. The first three were made by puddling, from pigs obtained at the Kentucky Iron Works, Greenup co., Ky. The last two were rolled from Juniata blooms, previously hammered

No. of the specimen.	Direction in which it was cut from the sheet.	Mode of manufacture.	DATE.	No. of the experim't.	Length of the bar before trial.	Breadth of the section of fracture before trial.	Thickness before trial.	Area of the section before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
42	Length,	Puddled,	1832. May 12,	1	23.8	.970	.252	.244440	73.5°	443	13290	664
42	"	"		2	22.45	.980	.252	.246960	73.5	452	13560	678
42	"	"		3	18.8	.978	.252	.246456	73.5	462	13860	693
43	Length,	Puddled,	"	4	23.2	1.140	.250	.285000	73.5	441	13230	661
44	Length,	Puddled,	"	5	23.7	1.048	.254	.266192	73.5	503	15090	754
44	"	"	"	6	17.9	1.048	.248	.259904	73.5	507	15210	760
46	Length,	Hammered plate,	"	7	24.4	.624	.242	.151008	68.	314	9420	471
46	"	"	"	8	19.8	.624	.242	.151008	68.	324	9720	486
48	Length	Hammered plate,	1832. May 19,	9	24.5	.976	.246	.240096	73.	503	15090	754
48	"	"		10	21.9	1.010	.246	.248460	73.	518	15540	777

TABLE XXXIV.

into slabs, and constituting "hammered plate." *These strips were all cut lengthwise of the sheets from which they were taken. The specific gravity of* 42, 43 *and* 44, *was* 7.682; *that of* 46 *and* 48, *was* 7.6785.

Effective strain.	Strength in pounds per square inch.	Weights under which elasticities were taken.	Elasticity of the bar.	Length after trial.	Area of the section after fracture.	REMARKS.
12626	51653	224 336 399 427 443	27. 32. 28.5 31. Broke.	23.9	.960×.236 =.226560	This fracture exhibited, in some parts, a smooth steel-like appearance, and in others a resemblance to cast iron.
12882	52162	399 427 452	28.5 31. Broke.	22.55	.960×.236 =.226560	Broke at an original section.
13167	53425	399 462 462	28.5 22. Broke.	18.9	.970×.236 =.228920	Do.
12569	44102	441	25.	23.35	1.120×.236 =.264320	Do.
14336	53836	224 336 448 476 496 503	25. 25. 26. 36. 34. Broke.	24.1	1.010×.228 =.230280	Did not break at the smallest section.
14450	55597			18.0	1.036×.242 =.250712	The thickness at the point of fracture had probably been reduced by the former strain.
8949	59262	224 280 297 314	29. 29. 28.5 Broke.	24.8	.570×.210 =.119700	Broke at a section deeply filed.
9234	61149			20.1	.578×.206 =.119068	
14336	59710	224 336 425 444 464 478 487 503	16. 18. 21.5 30. 27. 31. 28. Broke.	25.2	.896×.194 =.173824	Broke at a filed section.
14763	59418			22.15	.968×.204 =.197473	Original section.

TABLE XXXV.

Experiments on bars No. 51, 53, 56, *and* 58. *Manufactured by Henry Blake & Co., of Pittsburg. Cut crosswise of the sheets from which they were taken, the first two* (51 *and* 53) *from a boiler-plate of*

No. of the bar.	Direction of the slit.	Mode of manufacture.	No. of the exp'ts.	DATE.	Length of the bar before trial.	Breadth.	Thickness.	Area of the section of fracture before trial.	Temp. Fah.	Breaking w't.	Breaking w't. × leverage.	Friction.
				1832.								
51	Cross.	Ham'ed.	1	May 19.	24.	.874	.258	.225492	73	472	14160	708
"	"	"	2	"	21.5	.830	.258	.215140	73	472	14160	708
53	Cross.	Ham'ed.	3	"	24.	.972	.250	.243000	73	478	14340	717
"	"	"	4		21.	.956	.262	.250472	73	500	15000	750
56	Cross.	Puddled.	5		23.7	.918	.248	.227664	73	471	14130	706
"	"	"	6		20.3	.944	.258	.243552	73	495	14850	742
58	Cross.	Puddled.	7	May 26.	23.7	1.044	.244	.254736	62.5	452	13560	678
"	"	"	8	"	22.35	.986	.256	.252416	62.5	479	14370	718
"	"	"	9	"	20.7	1.002	.258	.258516	62.5	496	14880	744
"	"	"	10	June 30.		.738	.253	.186714	394	471	14130	706
"	"	"	11	"		.706	.246	.173676	81	448	13440	672
"	"	"	12	"		.696	.257	.178872	81	429	12870	643

TABLE XXXV.

of Juniata hammered, and the other two, from one of Kentucky puddled iron. The specific gravity of the former, 7.7567, *that of the latter,* 7.6511.

Effective strain.	Strength in lbs. per square inch.	Wts. producing temporary elongation.	Elasticity of the bar.	Length after fracture.	Area of section after fracture.	REMARKS.
13452	59656	224	53	24.5	.828×.224 =.186472	
		336	53			
		448	27			
		464	32			
		472	Broke.			
13452	62527			21.6	.800×.230 =.184000	Broke at the smallest section under the same weight which had broken the larger section in the first expt.
13623	56062	224	37	24.45	.948×.224 =.212352	Did not break at the *filed* section.
		336	36			
		448	21			
		464	22			
		478	Broke.			
14250	56892	494	25	21.4	.916×.234 =.214344	do. do.
		500	Broke.			
13424	58964	224	07	23.83	.898×.234 =.210132	Two different sect's. had been filed, one near the middle, another near the end of the bar. The frac. now took place at the latter.
		336	07			
		448	21			
		471	Broke.			
14108	57926	448	25	20.35	.926×.244 =.225944	This section had been near the middle of the bar in the preceding trial. The fracture was not now made in the narrowest part of the filed section. The breadth of that part after the fracture was .906, its thickness .258. Calculating for the same breaking weight on the narrowest part the strength exhibited was 59604.
		495	Broke.			
12882	50570	224	49	23.8	1.030×.214 =.220420	Broke near the wedges.
		336	54			
		392	50			
		448	44			
		452	Broke.			
13652	54085	448	26	22.45	.980×.238 =.233240	This and the two preceding experiments were on sections not filed, the three following were on filed sections intended to indicate the degree of weakness produced by the shears.
		479	Broke.			
14136	54681	479	57	20.8	.978×.234 =.228852	
		496	Broke.			
13424	71896				.715×.224 =.160160	Broke suddenly in hot oil.
12768	73516				The mean area by 10 trials is 87.8 per ct. of the areas of the same sections before trial.	The weight was raised from the floor by the screw, and subsequently taken up by the windlass still higher, but on letting it down again the bar broke. Result doubtful.
12227	68356					Broke short at the filed section but not so suddenly as in the 10th expt.

TABLE XXXVI.

Experiments on bars No. 59, 60, 61 and 62. Manufactured by H. Blake & Co., Pittsburg, by puddling and rolling into boiler-plate. The pigs obtained from the Kentucky Iron Works, Greenup county, Ky.

No. of the bar.	Direction of the slit.	DATE.	No. of the exp't.	Length before trial.	Breadth.	Thickness.	Area of the section of fracture before trial.	Temperature. Fahrenheit.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
59	Length,	1832. May 23,	1	23.51	.906	.168	.152208	66.°	258	7740	387	7353
60	Length,	Nov. 22,	2	23.55	.550	.170	.093500	59.75	200	6000	300	5700
60	"	"	3		.550	.170	.093500	567.5	240	7200	360	6840
60	"	Nov. 24,	4		.545	.172	.093740	54.	193	5790	289	5501
60	"	"	5		.523	.171	.089433	558.	226	6780	339	6441
60	"	"	6		.569	.175	.099575	61.5	212	6360	318	6042
60	"	"	7		.527	.168	.088536	61.5	191	5730	286	5444
61	Length,	May 23,	8	23.6	1.048	.182	.190736	66.	336	10080	504	9576
61	"	June 27,	9		1.030	.184	.189520	82.	364	10920	546	10374
61	"	"	10		1.057	.178	.188146	394.	349	10470	523	9947
61	"	"	11		1.051	.179	.188129	82.	378	11340	567	10773
61	"	"	12		1.020	.172	.175440	82.	378	11340	567	10773
61	"	"	13		.945	.170	.160650	394.	349+	10470	523	9947
62	Length,	July 18,	14		.697	.184	.128248	580.	315	9450	472	8978
62	"	"	15		.683	.186	.127038	570.	298	8940	447	8493
62	"	"	16		.722	.177	.127794	574.	329	9870	493	9377
62	"	"	17		.700	.177	.123900	82.	278	8340	417	7923
62	"	"	18		.676	.182	.123032	82.	252	7560	378	7182
62	"	"	19		.680	.180	.122400	82.	261	7830	391	7239
62	"	"	20		.727	.181	.131587	82.	266	7980	399	7581

TABLE XXXVI.

A part of the experiments made upon original sections, others on filed sections, in which nearly one-half of the original breadth of the bar was taken away. Specific gravity 7.6013.

Strength in lbs. per square inch.	Weight producing temporary elongation.	Elasticity of the bar.	Length after fracture.	Area of section after trial.	REMARKS.
48308	112	12.5′	23.7	.888×.152 =.135376	Broke at a section not filed, in the middle of the bar.
	168	20.			
	224	27.			
	242	27.			
	258	Broke.			
60963					Began with a filed section near one end of the bar.
73155					This section was about seven inches from the preceding.
58684					This section is the part between the two preceding.
72021					Temp. had been as high as 572°; having lowered the lamp, it fell at the moment of fracture to the point noted.
60678					Filed section as above.
61489					Do.
50211	224	40.	23.65	1.024×.166 =.169984	A section had been filed in the bar, which appears not to have been deep enough, as it did not break there. The *elasticities* were repeatedly taken under each weight, and are considered very accurate.
	280	42.			
	326	38.			
	332	36.			
	336	Broke.			
54738					Broke at once under the weight noted. The bar had now a filed section of .945×.170=.160650.
52869					Broke out of the filed section—which was the same as in the preceding experiment.
57264					
61405					The strength of the filed section must be *above* 10773÷.16065=67058 lbs., for that section was *not broken*.
61917					This calculation shows how much per sq. inch was borne by the filed section in experiment tenth.
70005					
66854					
73385					
63947					
58375					Broke immediately on applying the weight noted in the table.
59142					
57612					

TABLE XXXVII.

Experiments on bars No. 64, 65, 68, 70, 71 and 73. Manufactured by H. Blake & Co. of Pittsburg. The first two made by the process of puddling—the pigs obtained from Greenup county, Kentucky; the other four hammered into slabs from Juniata blooms, and then rolled into boiler-plate. The fractures

No. of the bar.	Direction of the slit.	Mode of manufacture.	DATE.	No. of the exp.	Length before trial.	Breadth.	Thickness.	Area of the section of fracture before trial.	Temp. Fah.	Br. weight in the scale.	Br. weight × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.
68	Length,	Hammered plate,	1833. Jan. 5.	1	24.0	1.096	.202	.221392	62.5°	450	13500	675	12825	57929
68	"	"		2	20.8	1.008	.200	.201600	62.5	455	13650	682	12968	64325
70	Length,	Hammered plate,		3	23.9	1.054	.214	.225556	65.	377	11310	565	10745	47638
64	Cross,	Puddled,		4	24.2	1.018	.208	.211744	73.	335	10050	502	9548	45092
65	Cross,	Puddled,		5	24.25	1.012	.200	.202400	65.	364	10920	546	10374	51255
65	"	"	Ja. 12.	6		.580	.189	.109620	46.5	242	7260	363	6897	62917
71	Cross,	Ham'red plate,		7	24.1	1.024	.164	.167936	62.5	357	10710	535	9175	54634
71	"	"		8	23.1	1.032	.170	.175440	62.5	414	12420	621	11799	67254
71	"	"		9		1.034	.170	.175780	62.5	440	13200	660	12540	71338
71	"			10		1.066	.182	.194012	62.5	459	13770	688	13082	67429
71	"	"		11		1.004	.208	.208832	62.5	465	13950	697	13253	63462
73	Cross,	Hammered Plate,		12	23.95	1.006	.184	.185104	73.	342	10260	513	9747	52657

TABLE XXXVII.

(with the exception of the second on bar No. 65, (exp't. 6 of the table,) were made at original sections, left by the shears. Specific gravity of 64 and 65.=7.6511; and that of 68, 70, 71 and 73=7.79.

Weight producing temporary elongation.	Elasticity of the bar.	Length after trial.	Area of the section after trial.	REMARKS.
224	32.'	24.45	1.040×.166 =.172640	Broke at an original section.
336	31.			
392	28.			
414	30.			
441	32.			
450	Broke.			
224	32.	20.9	.952×.188 =.178976	Do.
448	20.			
455	Broke.			
112	19.5	24.05	1.008×.192 =.193536	Original section—Broke with the rising motion of the lever while taking up the screw. The friction is therefore to be added. Under a strain of 280, measured a certain portion and found it 16.7 inches long; under 336 lbs. it was 16.9; under 364 lbs. 17.05, and with 377, 17.1 inches. Extension 17.10—16.7=.4 in. or 2.4 per cent.
224	16.			
280	19.			
336	23.			
364	26.			
377	Broke.			
112	38.	24.3	1.014×.202 =.204828	Original section.
224	55.			
280	51.5			
301	52.5			
329	46.			
336	Broke.			
224	19.	24.3	1.012×.188 =.190256	Original section.—A portion of this bar, 17.85 inches long when under a strain of 336 lbs., was found to be only 17.817 when the strain was off. recoil .033=1—540th of the whole length.
280	18.			
336	27.			
364	Broke.			This was a deeply filed section made for the purpose of ascertaining the weakening effect of the shears.
224	20.	24.22	.986×.130 =.128180	Broke at an unfiled section at the gripe of the wedges.
336	27.			
357	Broke.			
336	28.		1.012×.126 =.127512	Broke again at an unfiled section.
392	26.			
414	Broke.			
			1.012×.136 =.137632	Do.
			1.056×.156 =.164136	Do.
				After this exp't. the bar, which had at first been 24.1 inches long, was found to be 25.3;—gain one and two-tenths by 5 fractures.
112	05.5		.960×.160 =.153600	Broke at an unfiled section.
224	11.			
280	18.			
308	19.5			
322	33.			
336	24.			
342	Broke.			

TABLE XXXVIII.

Experiments on bar No. 49. Manufactured from Juniata blooms, hammered into boiler plate, by Messrs. H. Blake & Co., of Pittsburg,

Marks.	Breadth.	Thickness.	Area before trial.
0	.745	.205	.150675
1	.744	.206	.153264
2	.745	.209	.155705
3	.745	.211	.157195
4	.747	.211	.157617
5	.747	.210	.156870
6	.747	.210	.156870
7	.748	.210	.157080
8	.748	.212	.158576
9	.748	.211	.157828
10	.746	.210	.156660
11	.744	.211	.156984
12	.744	.211	.156984
13	.745	.210	.156450
14	.747	.211	.157617
15	.748	.212	.157576
16	.745	.210	.156450
17	.746	.210	.156660
18	.747	.211	.157617
19	.742	.209	.155078
20	.744	.208	.154752
20.3	.739	.210	.155190

Measures taken after the 4th fracture with 343 pounds.			
0	.725	.195	.141375
1	.702	.195	.136890
2	.713	.197	.140461
3	.730	.206	.150380
4	.728	.204	.148512
5	.729	.204	.148716
6	.726	.206	.149556
7	.728	.202	.147056
8	.729	.202	.147258
9	.725	.200	.145000
10	.718	.200	.143600
11	.720	.200	.144000

Marks.	Breadth after trial.	Thickness after trial.	Area after trial.
Measures after 1st fracture.			
0	.731	.200	.146200
1	.724	.201	.145524
2	.726	.202	.146652
3	.735	.208	.152880
4	.732	.207	.151524
5	.738	.209	.154342
6	.739	.206	.152234
7	.740	.207	.153180
8	.736	.205	.150880
9	.730	.203	.148190
10	.726	.202	.146652
11	.718	.201	.144318
12	.719	.203	.145958
13 (Smallest section and place of first fracture.)	.675	.181	.122175
14	.728	.201	.146328
15	.734	.206	.151204
16	.732	.202	.147864
17	.726	.201	.145926
18	.722	.201	.145122
19	.726	.203	.147378
20	.718	.200	.143600
20.3	.728	.199	.144872

No. of the exp's.	Area of the section of fracture before trial.	Temp. Fah.	Breaking wht. in the scale.	Break. wht. × leverage.
1	.156450	65	316	9480
2	.156984	440	322	9660
3	.153264	574	335	10050
4	.156975	572	343	10290
5	.156822	65.75	361	10830
6	.156450	65.	369	11070
7	.157244	65.	369	11070
8	.157406	65.	377	11310
9	.154971	65.	337	10110
10	.156347	61.5	337	10110
11	.157138	61.5	337	10110
Mean of 11 =	.156368			
Mean of 22 orig. meas. =	.156359			
Max. of do. =	.158576			
Min. of do. =	.150675			
Mean of these two =	.154625			
Difference of the two =	.007901			

TABLE XXXVIII.

Pa. This strip was cut lengthwise of the sheet and then reduced to uniformity by filing. Specific gravity, 7.6875.

Friction.	Effective strain.	Strength in lbs. per sq. inch.	DATE.	Wt. produ. elon. before fracture.	Effects of the weights applied.	Points fractured.	REMARKS.
			1832.	lbs.			
			Nov. 29.	238	no perm. elonga.		Began by trials to ascertain the commencement and progress of elongation.
				245	perman. elongat.		
				259	20.3 had extended .15 in.		The length on which measurements were taken was originally 20.3 inches.
				266	.20		
				273	.30		
				280	.36		After this strain was taken off the bar recoiled 1-20 inch in length.
				294	.38		
				301	.58		Taking this strain off it recoiled 6-100 inch.
				306	.95		On taking off this strain it recoiled 4-100 in.
				313	1.14		do. do. 4-100
				316	1.42		The bar of 20.3 inches now measured 21.72.
						No.	
474	9006	57565	Dec. 1.			13	Broke at the smallest section in the bar.
483	9177	58458	"			11½	Part in tin from 5 to 8 inclusive. Fracture very near the wedges.
502	9548	62798	Dec. 6.			1	Broke near the wedges; arrested the motion before the bar actually parted.
514	9776	62278	"			6½	Fracture in the tin short and sudden.
541	10289	65609	"			10½	Broke within the wedges.
553	10517	67223	"			2½	Had not been in tin.
553	10517	66883	"			9½	Had been near the tin.
565	10745	68263	"			3½	
505	9605	61919	"			20	A different piece from the preceding.
505	9605	61434	Dec. 8.			18½	
505	9605	61121	"			17½	Broke after some delay.
							The mean area of the sections fractured was .000009 square inch *greater* than the mean area of the measured points.
							The mean area of the 12 measured points from 0 to 11 was, before trial, .156277; after the first fracture, .149381; and after the fourth fracture, .145233. Hence the increase of length by a strain of 9006 lbs. was 4.4 per cent., and by 9776 lbs. it was 7 per cent.

TABLE XXXIX.

Experiments on bar No. 74. Manufactured by H. Blake & Co. Pittsburg, from Juniata blooms. Hammered and rolled, making what is termed hammered plate. *This, and numbers* 71, 72 *and* 73, *were from a strip, cut* across *the sheet. The specific gravity of these four bars was*

Marks.	Breadth.	Thickness.	Area before trial.	Marks.	Breadth after trial.	Thickness after trial.	Area of section after trial.	DATE.	No. of the experiment.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.
				Measures after the first frac.								
0	.770	.174	.133980									
1	.760	.166	.126160	0	.766	.173	.132518	1833.				
2	.765	.165	.126225	1	.759	.165	.125235	Jan. 10,	1	.125895	59.5°	218
3	.762	.167	.127254	2	.763	.163	.125895					
4	.765	.167	.127755	3	.759	.167	.126753					
5	.764	.168	.128352	4	.757	.167	.126419	Jan. 12,	2	.119886	48.	224
6	.761	.168	.127848	5	.761	.165	.125565					
7	.761	.166	.126326	6	.758	.166	.125828					
8	.765	.165	.126225	7	.746	.160	.119360	"	3	.126442	48.	225
9	.765	.166	.126990	8	.750	.161	.120750					
10	.765	.165	.126225	9	.755	.162	.122310					
11	.765	.165	.126225	10	.748	.161	.120428	"	4	.126390	49.5	229
12	.759	.164	.124476	11	.736	.158	.116288					
13	.759	.165	.125235	12	.724	.154	.111596					
14	.763	.165	.125895	13	.725	.158	.114590	"	5	.126225	550.	224
15	.765	.166	.126990									
16	.766	.165	.126390	Mean of 14= .124129								
17	.768	.164	.125952									
18	.768	.163	.125184	Mean of the same 14								
19	.768	.163	.125184	sections before trial,				"	6	.130070	564.	266
19.6	.754	.159	.119886	.127991. Diminution								
				.002962=2.3 per cent.								
Mean of 21			.125840					Jan. 19,	7	.126607	52.	280
Maximum			.128352									
Minimum			.119886					"	8	.126326	52.	291
Mn. of these 2			.124119									
Diff. of the 2			.008466					"	9	.126568	52.	295
								"	10	.127755	52.	295
								Mean of 10		.126216		

TABLE XXXIX.

found to be 7.7910. *The bar was two feet in length, of which a section* 19.6 *inches in length was filed and gauged, and two end sections, about* 1 *inch wide and* 2 *inches each in length, were left to be grasped by the wedges in the first trial.*

Breaking weight multiplied by leverage.	Friction.	Effective strain.	Strength in lbs. per sq. inch.	Point of fracture.	REMARKS.
6540	327	6213	49351	No. 14	Stretched very much before breaking.
6720	336	6384	53250	" 19.6	
6750	387	6363	50332	near 14½	Point of frac. not precisely ascertained.
6870	343	6527	51641	" 16	
6720	336	6384	50576	" 11	Part in tin from 5 to 8 inclusive. Temp. had been as high as 640°. Broke near the wedges—as far as possible from hot part.
7980	399	7581	58284	" 0½	Part in tin 4 to 7 incl. Fracture at the extremity of the parts included between the wedges, as far as possible from the hot part. Temperature had been as high as 602°.
8580	429	8151	64380	" 8½	
8730	436	8294	65655	" 7	
8850	442	8408	66431	" 2½	
8850	442	8408	65813	" 4	The mean area of the 10 sections of fracture is .000376 sq. inch *greater* than that of the 21 measured sections.

TABLE XL.

Experiments on bars No. 75, 78, 85, 86 and 87. Manufactured at the Juniata Iron Works, near Pittsburg, by Messrs. Schoenberger & Son, from blooms, by hammering and rolling. These were all cut off

Number of the bar.	Direction of the slit.	Number of the experiment.	DATE.	Length before trial.	Breadth.	Thickness.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
85	Length.	1	1832. May 10,	24.5	1.040	.260	.270400	66	462	13860	693	13167
85	"	2		22.1	.990	.254	.251460	66	481	14430	721	13709
85	"	3			.928	.250	.232000	66	492	14760	738	14022
86	Length.	4			.675	.256	.172800	580	394	11820	591	11229
86	"	5			.687	.256	.175872	580	406	12180	609	11571
86	"	6			.677	.257	.173989	90	360	10800	540	10260
86	"	7			.678	257	.174246	32	381	11430	571	10859
86	"	8			.715	.257	.183755	32	420	12600	630	11970
87	Length.	9		24.5	1.028	.256	.263168	66	464	13920	696	13224
87	"	10		19.	1.060	.260	.275600	66	506	15180	759	14421
75	Length.	11		24.6	.664	.182	.120848	67	262	7860	393	7467
75	"	12		21.4	.724	.184	.125976	66	267	8010	400	7610
75	"	13			.675	.184	.124200	396	272	8160	408	7752
75	"	14			.672	.188	.126336	86	262	7860	393	7467
78	Length.	15		24.4	1.028	.186	.191208	73	280	8400	420	7980
78	"	16			1.014	.186	.188604	73	293	8790	293	8351

TABLE XL.

lengthwise of the sheet and tried either at original or at detached filed sections. Specific gravity, **7.7580.**

Strength in pounds per square inch.	Weight producing temporary elongation.	Elasticity of the bar.	Length after trial.	Area of section after trial.	REMARKS.
48694	112	11.5		1.036×.240 =.248640	Broke at an unfiled section.
	224	15.			
	336	33.			
	392	38.			
	420	36.			
	448	24.			
	462	Bro.			
54518	224	15.	22.25	.954×.240 =.228960	Broke at an unfiled section.
	336	23.			
	392	24.			
	462	28.			
	481	Bro.			
60440				.894×.218 =.194892	Broke at the filed section.
64983					
65791					
58969					
62360					
65141					
50249	224	21.	24.7	1.028×.184 =.189888	A filed section had been made with an area of 1.012×.256=.259072, but the frac. took place at an unfiled sect. Two or three flaws were disclosed near the filed section.
	336	16.			
	392	25.			
	441	25.			
	464	Bro.			
52326				1.050×.234 =.245700	The filed sect. in this exp. had an area of .270920=1.042×.260.
61788	257	8.	24.7	.650×.160 =.105000	A short piece only, embraced between the heads.
	262	Bro.			
60408	168	10.			
	267	Bro.			
62415					Broke outside of oil, near wedges.
59104					Broke at the filed section.
41734	112	14.5	24.52	1.004×.160 =.160640	A part of this bar, 15.5 in. long, had become 15.55, under a strain of 280 lbs., but without the tension it was 15.525. Stretched rapidly, and at last broke with a weight of 280 lbs.
	224	17.5			
	280	21.			
	280	Bro.			
44278	224	54.			
	293	Bro.			

Methods of Manufacturing Boiler Iron.

For the information of the general reader who may not be familiar with the several processes in the manufacture of iron, referred to in some of the preceding, and in several of the subsequent tables, it may be proper here to offer a few remarks explanatory of the methods pursued in the United States for producing wrought iron of the descriptions embraced in this part of the report.

It has already been stated that the iron furnished to the committee was, with a single exception, manufactured by the aid of charcoal. This remark applies, of course, to the first process, that of *smelting* it from the ore, which is, for the most part, performed in the usual blast furnaces from 30 to 40 feet in height, and about 8 feet in their greatest interior diameter, producing the different varieties of *pig metal.*

It has been mentioned to us, that in Missouri, this process is sometimes dispensed with, especially when working the ore of the "iron mountain," a rich, heavy, magnetic oxide, of a bluish or iron grey colour, and of the extraordinary specific gravity of 5.36. The ore is there put into open forge-fires resembling the Catalan Forges of the south of Europe, and by a similar treatment to that which there prevails, brought at once to the condition of malleable iron without passing through the state of *cast* or *pig* metal.

The process of manufacturing blooms, or, as they are, when intended for boiler plate, technically termed, "*blocks*," is to subject the pig metal of the blast furnace to the combined action of heat and air in an open forge-fire of charcoal, drawing off the melted cinder or "slag" by a suitable opening; and after stirring and compacting the iron as it begins to agglutinate, or "come round to nature," to carry the ball to the heavy forge-hammer, and form it into a prismatic mass, from 15 to 20 inches in length, and from 5 to 9 inches in diameter, according to the weight of the plate intended to be obtained from it. These *blocks* when taken to the rolling mill are heated in an air furnace supplied generally with bituminous coal as a fuel, and at the first heat are reduced by a heavy hammer into slabs 2 or 3 inches thick, and of a length nearly corresponding with that of the blocks. This operation discharges much of the remaining cinder, and other impurities left in the block by the *bloomery* treatment. At the second process they go to the *rolls* where they are placed first, with the length of the slab corresponding in direction with that of their axes; secondly, with the length of slab *across* the diameter of the rolls, until it has been increased to the required breadth of the finished sheet; and finally, by placing the original length of slab once more parallel to the axes, and extending the plate till it has been reduced to the requisite thickness.

Sheet iron by the process of *puddling*, is, for some purposes, manufactured from pig metal into malleable iron, without the intervention of any other process of refining, than that which takes place in the puddling furnace itself. But for boiler plate, it is believed to be customary, first to subject it to the action of the "run-out" refinery fire, in an open charcoal, or coke furnace urged by a powerful blast. As, in this fire, a large mass of metal is melted down at a time, and the cinder drawn off separately, the earthy impurities which in simple puddling would be retained in the balls, are at once removed, and by the aid of a small stream of water which is occasionally made to accompany the blast, a partial decarbonization of the metal is probably effected. When in full fusion, the metal is drawn off or "run out" into an oblong bed, and while still hot, is broken up into blocks of a few pounds weight each, to be conveyed to the puddling furnace. In the latter it under-

goes a second fusion, and the usual operation till agglutinated into "balls." Bituminous coal is the fuel here employed, and the furnace is of the reverberatory form. The balls pass from this furnace first to the large hammer, by which they are moderately compacted; and immediately after to the rolls by which they are reduced into broad bars or slabs. The latter are reheated and at once rolled into plate, the former cut up into lengths of about 15 or 18 inches and piled, three high, to be reheated and welded into slabs of sufficient magnitude for plates of boiler iron.

[TO BE CONTINUED.]

On Calcareous Cements. By JAMES FROST, Civil Engineer.

Essay VI.

(Continued from p. 195.)

As this new state of protoxide of silicon has never been observed, or at least not described, by chemists in any work that has ever come under my observation, and as it is essential to understand it—to explain how silex is always displaced from its combinations with lime, and yet how silex in cements, apparently the same substance, is not displaced but always exhibits, as I shall show, for ages a superior affinity for lime.

This peculiar state of silex seems permanent for the following reasons:

First, In specimens of Roman cement, twenty to thirty years old, the silex remains soluble in acids.

Second, In numerous specimens of indurated mortar, from very ancient bridges, churches and castles in England, including Cæsar's Tower in Dover Castle, perhaps the oldest mortar in England, a portion of silex was soluble.

Third, In Terras and in Pozzolana volcanoes, both the products of ancient columns, a quantity of silex is soluble in acids, and the efficiency of those substances in water mortars is in just proportion to the quantity soluble. Now this fact, if established by further observation, may prove useful in geological investigations; and as I have examined most of the principal limestones of England and Wales, and many in this country, without ever finding soluble silex therein, if this position be true, these limestones have never been subjected to great heat, an assertion often made by some geologists.

The only case given to the contrary, is a statement of Monsieur Vicat, who describes a species of limestone as found somewhere in France holding soluble silex.

Monsieur Vicat having written the most copious treatise extant on Lime and Cement, and having condensed therein almost all that had been written by other authors, he is considered the best authority in these matters, and any mis-statement of his may cause serious errors. He observes that silex and alumina are the only, and always equally, essential adjuncts to lime in hydraulic compounds, and though he has been unable to discover the best proportions of each, yet asserts both are essentially necessary. The following experiments, showing the real nature of their qualities, will show the error of this opinion, and I shall take a future opportunity of controverting another of his postulates.

Ten parts finely pulverized chalk, intimately mixed with each of the following proportions of the substances in fine powder, were formed with water into cakes, dried and calcined in a reverberatory furnace, at a white heat, for ten hours, and cooled in atmospheric air by withdrawing the fuel

from the furnace, were finely pulverised, tempered with water as mortar, and behaved as follows:

A.—One part silex, slacked hot in a few seconds.

B.—Two parts silex, became warm and slacked in about a minute.

C.—Three parts silex, became tepid, and set in ten minutes, a good cement.

D.—Four parts silex, hardly set in twelve hours, quite cold, remained tender many days, yet at the end of some months became a tolerably hard cement.

A2.—Repulverised, remade, recalcined, retempered with water, became warm and slacked in three minutes.

B2.—Recalcined, remade, and became tepid; set as a good cement, and ultimately obtained great hardness.

A3.—Repulverised, and recalcined, and remade, and tempered with water the third time; as at first, set rather warm, but remains a permanent cement, as I possess a specimen of each of the above, which have been exposed to all changes of weather for ten years.

E.—One part pure alumine, set instantly with great heat and slacked, or rather exploded, in a few seconds.

E.—On being repeatedly recalcined, &c., exhibited several times in succession the same symptoms.

F.—Two parts pure alumine, became hot and slacked in a minute, and behaved the same on a second and third trial.

G.—Three parts pure alumine, set quick and warm, but in appearance a handsome white cement, yet fell to pieces in a few days, and on being subsequently recalcined and remade always went to pieces at short intervals.

H.—Four parts pure alumine, set cool, quickly; as a most promising and beautiful white cement, much resembling fine plaster Paris, becoming very strong in a few minutes; much exceeding the silicate in this respect, but always, and on repetition, fell to pieces at intervals of a month or two.

I.—Various proportions of pipe clay, consisting par analysis of three parts silex, one part alumina, and a very slight trace of oxide of iron; the most promising proportions being four parts pipe clay, set cool in a few minutes, apparently good and beautiful cements, hardening slowly but moderately; they all sooner or later went to pieces, seldom lasting three months, while in no instance did the purely silicious fall to pieces. except at the instant of setting.

To ascertain the cause of this difference in their habits, a weighed portion of each of D. and H. were placed on separate papers, moistened with water, covered with other papers in a cool room, and at intervals of a day or two, the papers were placed on a stove, heated for one hour to 300 Fah. and weighed, the powders being again moistened, reposed a day or two, reheated and weighed, and this process continued for a month or so; when the silicious compound D. had scarcely increased in weight, and on being tested with acids—effervesced but slightly.

The aluminous compound H. had increased in a weight equivalent to the dose of carbonic acid and also nearly to the additional weight of the alumina therein, strongly effervesced with acids, the lime had become carbonate, the alumina hydrate, plainly shewing that the lime had a greater affinity for carbonic acid than for alumine.

But as alumine, placed in lime-water, is cemented by the deposition of

lime, and as a mixture, or mortar, of pure alumine and lime, placed under common water, concretes and slowly hardens to the consistency of common chalk, it is evident that lime has a greater affinity for alumina than for water, and while protected from carbonic acid, this union is durable, but no longer, as we see, and this account of the habits of alumina, enables us to explain how some cements may gradually harden under water, and unharden in air.

Pure alumine prevents the regular action of the affinities between lime and silex; in no case could I obtain a cement with any proportion of pipe clay, not exceeding three parts. Now as three parts pipe clay is composed of two and a quarter silex, and as a cement can be obtained with one part silex, the controlling power of alumina is very strong.

The seeming difficulty of obtaining a cement with one part silex, is doubtless only owing to the infusibility of that substance, a small addition of either carbonate soda, carbonate potassa or muriate soda, generally ensures a cement at first calcination, but as these additional saline matters, always exhibit an ulterior effervescence, they injure the otherwise beautiful appearance and stone-like aspect.

Silex then is the substance, in the smallest quantity combining with lime to form cements. The protoxides of iron and of manganese possess the same powers, but must be used in at least double quantities; and then the cements are of very inferior hardness; but they are permanent, for I possess some of many years age.

But the most remarkable effect of the protoxides of iron and of manganese, is the power possessed by those substances in counteracting the influence of alumina. If to 3½ parts pipe clay be added a half of oxide of iron or of manganese, (for metallic iron has no influence) or a mixture of both, and all well incorporated with ten parts chalk, calcined and treated as before, a cement is obtained of the same character, colour, hardness and durability as the various kinds of Roman cement, manufactured and used in England and in this country, for many years on a prodigious scale. Large quantities of cement are now made in England from artificial mixtures of chalk with natural clays, possessing the aforesaid properties, and being of a pleasant colour and low price promise to be exceedingly useful.

A small quantity of magnesia, also, possesses the property of counteracting the influence of alumine, and produces as good an effect as the oxides of manganese and iron, with this additional advantage, it produces a cement of a beautiful colour for architectural purposes. Admixtures of magnesian clays, either containing oxides of iron or manganese or not, will always be found useful additions in compounding artificial, argilo-calcareous cements.

That magnesia should be found useful in such compounds, seems no ways wonderful, when we learn its unique affinities for water, it being a water cement of itself, which no other earth is; and it is a fact of which all medical men should be particularly aware, as they prescribe it extensively as a mild and safe purgative, and which it is when acetic acid is present in the system, which combining forms an acetate, an aperient; if the acid is not present, the magnesia is considered a tasteless, mild, inert, earthy substance, that can produce no injurious action in the human system. This opinion is very dangerous, instead of being inert when mixed with water, it is (what lime is not) per se, a real water cement, and if long detained in the system may prove of fatal consequence.

This fact has been long overlooked from the slow manner in which magnesia sets, so contrary in fact to the description of it in chemical works

wherein it is said to slack with heat on the application of water; while the fact is, it remains quite cold, and wet, and pasty for many hours; but placed under water it always, though not till the lapse of twenty or thirty hours, concretes into a solid substance, and gradually acquires about the hardness attained by plaster of Paris, and particularly under water, for though it sets and hardens in air it cracks therein, by evaporation of the water, before the magnesia can consolidate.

As the carbonate of magnesia is equally aperient in an equivalent (double) quantity when acetic acid is present in the system, and as a carbonate cannot become a cement, it follows, that harmless and equally useful preparations should always be preferred.

The affinities of magnesia for water and carbonic acid, are singularly feeble; lime combines with its equivalent of water, instanta, and if formed in a thin stratum and exposed to the atmosphere, quickly becomes carbonate; not so with magnesia. I have had a small cake of only 200 grains of magnesia, tempered with water for seven years, exposed to all weathers and situations; I have kept it for months in cellars in which fermenting liquors were stored, kept it wet or dry, yet it now weighs less than 230 grains, and a part of that weight it loses by being dried at a temperature of 212° Fah.

Magnesia not only remains cold when moistened with water, but communicates a cooling property to cements when it is present in them in small quantities; all good calcareous cements on setting, exhibit a slight warmth, proportioned to their freshness and quick setting, but the presence of a small quantity of magnesia will render them slower in setting and comparately cool or cold in proportion to the quantity of that substance.

Magnesia then is useful in cements, in small quantities; in larger quantities it is to be considered per se as a cement, but deserving no preference on that account only, as it acquires, of itself, but little hardness; and this as we have seen arises from its incapacity to combine with an equivalent of water or carbonic acid. The 200 grains of magnesia should have acquired an additional weight of 90 grains by becoming a hydrate, and 220 grains by becoming a carbonate, yet it has not acquired 30 *grains* in seven years, with every advantage of doing so; it, therefore, seems incapable of assuming or of re-assuming its former state; this may be a fact also deserving the attention of geologists.

Improvement on the Wing Gudgeon.

TO THE EDITOR OF THE JOURNAL OF THE FRANKLIN INSTITUTE.

Sir—My attention was drawn, a few days ago, to one of my water wheel (wing) Gudgeons. From some cause or other the neck of one got twisted off, and in looking to it, I thought I could make an improvement upon it. If you think it worth the trouble, and I am sure it will, you can publish it in your valuable work. What I claim is an additional neck exactly on the opposite side of the common wing gudgeon. It can be put into the shaft without the least inconvenience, and when the outer one is worn, or broken off, it can be turned and then you have a new one. This will save a great deal of time, particularly in establishments distant from a furnace, and nineteen-twentieths of the cost, as the additional neck, when made in the first instance, will not be fifty cents.

Yours, &c.

Edward Sims.

Virginia Mills, Buckingham Co., Va.

Experiments on the adhesion of Iron Spikes of various forms when driven into different Species of Timber. By Prof. WALTER R. JOHNSON.

In reference to rail-road constructions, bridge building, and several other useful applications in civil engineering as well as in naval architecture, the adhesion of spikes, bolts, and nails of various forms becomes an object of much practical importance. With regard to rail roads this matter is worthy of more attention than might at first sight be supposed. Owing to the present high price of iron, the flat rail is often unavoidably adopted in preference to the edge rail, and whenever the speed of a train, descending by gravity or impelled with great velocity by the moving power, is to be suddenly checked by the brake, the friction of the periphery of the wheel on the rail tends to drive the latter lengthwise and thus to force all the spikes with which it is fastened, into closer contact with the ends of the fibres which have been cut in driving them. If this partial or total dragging of the wheels along the rails takes place, sometimes in one direction, and sometimes in the other, the spikes must be subjected to alternate impulses on opposite sides. Indeed, whenever the motive power depends on friction for its efficacy, as in the case of the common locomotive engine, there is a constant succession of these two opposite dragging forces, the engine constantly tending by its driving wheels to urge the rail backward, and the train by an equal, but more extensively distributed action, tending to urge forward all the rails over which it is, at the same moment, passing. So decided is this influence, that on a rail-road where the transportation is all in one direction, and where the cars descend by gravity; I have seen rails entirely detached, or loosely connected but by a single spike, while others clearly indicated by the inclined position of their upper faces or heads, that they were pressed into an oblique or leaning position in the wooden sill. This single case may serve to show the importance of attending to the character of the spikes used in similar constructions.

To determine some of the points relating to the form of spikes, and the kind of timber into which they are driven, the following experiments were undertaken; they serve to show the relative economy of each form of spike, as well as its absolute fitness for the purpose intended.

The mode of executing the experiments was to drive each spike to a certain distance, above its cutting edge, into the edge of a piece of plank or scantling, and, by means of a suitable apparatus adapted to that purpose, to draw it out by a direct longitudinal strain. The machine employed for this purpose was the same as that which has been used for testing the strength of iron and copper in experiments on the tenacity of materials employed in steam boilers. A strong band or strap of iron connected with the weighing beam of that machine held the piece of plank, and a clasped pincers with a suitable jaw, for taking hold of the head and projecting part of the spike, was attached to the opposite part of the machine, which being tightened by a strong screw, held the spike firmly while the application of weights upon the longer arm of the lever drew the timber away and released the spike. Care was taken to cause the strain to pass through the axis of the spike, and by a very gradual application of weights, to avoid surpassing that force which was just sufficient for its extraction.

The first experiment was upon one of Burden's patent square spikes with a cutting edge, intended to be, in all cases, placed across the grain of the timber. This spike was .375 inch square, and was driven into a sound plank of seasoned Jersey yellow pine $3\frac{3}{8}$ inches. The force required to

extract it was 2052 lbs. The exact weight of the part driven into the wood was 866 grains troy.

The second trial was upon a flanched, grooved and swelled spike, having the grooves between two projecting wings or flanches on the same sides as the faces of the cutting edge. The other two sides were planes continuing to the head. A cross section of this spike taken $1\frac{3}{4}$ inches above its edge or point had the form of the figure annexed. At $\frac{8}{10}$ of an inch from the edge, that is where the flanches project least or where the *swell* between them comes nearest to forming a perfect square, the figure is as follows:—the dotted line *e e* in each figure representing the direction of the cutting edge.

Towards the head of this spike, the flanching and grooving is suppressed and the form becomes a square. This experiment was made on the same piece of Jersey yellow pine as the first, and the weight required for extracting the spike was 1596 lbs.; the weight of the part driven in was $708\frac{1}{4}$ grains. The cutting edge was ragged and irregular. The distance to which it was driven was $3\frac{3}{8}$ inches, as in the first trial. To know the relative values of the two forms of spikes we have but to divide the weight required for the extraction of each by the number of grains in the part which had been buried in the wood. Thus $2052 \div 866 = 2.37$, and $1596 \div 708.25 = 2.112$. Hence the plain spike had an advantage over the swelled and grooved one in about the proportion 23 to 21. It should be mentioned, also, that the plain spike was drawn out by a very gradual addition of force; whereas the force of 1596 lbs. drew the grooved spike immediately after its application. In the first trial an attempt was made to detect any yielding or gradual retreat of the spike before the final start, but none was perceived.

The third and fourth experiments were made with the same spikes respectively as the first and second; but instead of yellow pine the timber employed was thoroughly seasoned white oak.

The plain spike driven $3\frac{3}{8}$ inches into that timber, required for its extraction a force of 3910 lbs., and, as before, exhibited no signs of movement until the instant of starting, when it suddenly came out about a quarter of an inch, or as far as the range of motion, and the elasticity of the machine would permit.

The flanched, swelled and grooved spike driven $3\frac{3}{8}$ inches into another part of the same piece of plank, from which the plain one had been extracted, was drawn out with a force of 3791 lbs. A slow motion to the extent of $\frac{1}{25}$ or $\frac{1}{20}$ of an inch was in this trial perceived to precede the starting of the spike; and was accompanied by a gradual protrusion of the fibres of the timber immediately around the iron.

In these experiments though the plain spike bore the greater absolute weight, yet, when the weight of metal is considered it is seen that the relative values of the two are 4.515 in the plain, and 5.354 in the grooved form.

The various circumstances of the four preceding experiments are seen at a single view in the following table.

Table I.

No. of the experiment.	Description of spike used	Kind and condition of timber.	Breadth of the spike.	Thickness of the spike.	Depth to which it was driven.	Weight in grains of the part driven in.	Force required to extract it in lbs. avoirdupois.	Ratio of the extracting power to the w't of spike	Date.	Remarks.
			inch.	inch.	inches.					
1	Plain square spike, (Burden's.)	Seasoned Jersey yellow pine.	.375	.375	3.375	866	2052	2.368	Oct. 27, 1835	Force gradually applied; no motion previous to the start.
2	Flanched, grooved and swelled	Do.	.375	.300	3.375	708	1596	2.254	Do.	Force applied; at once.
3	Burden's plain.	Seasoned white oak.	.375	.375	3.375	866	3910	4.515	Do.	Started suddenly
4	Grooved and swelled.	Do.	.375	.300	3.375	708	3791	5.354	Do.	Fibres protruded 1-20 of an inch before the spike drew out.

Hence it appears that in yellow pine the grooved and swelled form was about five per cent. less advantageous than the plain, while in the seasoned oak the former was 18½ per cent. superior to the latter. It is also apparent that the advantage of seasoned oak over seasoned yellow pine for retaining spikes is, by a comparison of experiments 1 and 3, as 1 to 1.9; and by a comparison of 2 and 4 it is as 1 to 2.37. In the preceding experiments the spikes were driven into the timber and immediately drawn out again. In the second series, the spikes were driven into their respective pieces of timber and then soaked for a few days in water. The pieces into which different spikes were driven, were as nearly alike as it was practicable to obtain them, being always cut from the same plank avoiding knots, cracks, &c. The following table contains a view of the experiments made after soaking the timber.

Table II.

Timber soaked after Spikes were driven.

No. of the experiments.	Kind of spike used.	Kind and condition of the timber.	Breadth of the spike.	Thickness of the spike.	Depth to which it was driven.	Weight in grains of the part inserted.	Force to extract the spike in lbs.	Ratio of extracting force to weight of spike.	Date.	Remarks.
1	Swelled and grooved.	Chestnut unseasoned	inch. .375	inch. .300	inch. 3.5	806	1710	2.121	Dec. 3, 1835	In this and the four following experiments the thickness of the spike is that found at the bottom or hollows of the grooves.
2	Do.	Yellow pine seasoned.	.375	.300	3.5	806	1668	2.069	Do.	
3	Do.	Hemlock partly seasoned.	.375	.300	3.5	806	1738	2.156	Do.	
4	Do.	White oak seasoned.	.375	.300	3.5	806	3373	4.184	Do.	The oak used in this exp'nt was firmer than that employed in the first series.
5	Do.	Locust partly seasoned.	.375	.300	3.5	806	4902	6.081	Do.	The timber had been slightly split by driving.
6	With the swell filed away.	Unseasoned chestnut	.390	.300	3.5	759	1852.5	2.440	Do.	The flanches remained after filing out the swelled part of the original form.
7	Do.	Seasoned yel. pine.	.390	.300	3.5	759	1767	2.328	Do.	
8	Do.	Hemlock partly seasoned.	.390	.300	3.5	759	1296.8	1.576	Do.	
9	Plain spike draw filed lengthwise.	Chetnut unseasoned	.400	.394	3.625	933.5	1790	1.810	Do.	
10	Do.	Hemlock partly seasoned.	.400	.394	3.5	933.5	1638.75	1.755	Do.	
11	Do.	Locust partly seasoned	.400	.394	3.5	933.5	3990	4.167	Do.	
12	Do.	Do.	.400	.394	3.5	933.5	4332	4.640	Do.	Timber slightly split in driving the spike.
13	Grooved & notched or serrated.	White oak.	.392	.315	3.625	759	2622	3.454	Do.	
14	Burden's patent.	Do.	.339	.329	3.625	639	2152	3.367	Do.	

The first five of the preceding experiments show that with a spike of given form, and driven a certain distance into different timbers the order of retentiveness beginning with the highest is, as follows: 1. Locust; 2. White Oak; 3. Hemlock; 4. Unseasoned Chestnut; 5. Yellow Pine.

From the 6th, 7th and 8th experiments, we see that chestnut is still above yellow pine, but that hemlock is inferior to both. By the 9th and 10th, it also appears that hemlock is still to be placed below chestnut. Comparing the first experiment in this table with the 6th, and the 2d with the 7th, we perceive that the swell towards the point of the grooved spike was so far from being an advantage to it, that it, in fact, rendered the spike less retentive than when that swelled part had been removed, so that even could this form have been produced without any increase in the weight of the spike, it would still have been less advantageous than the simple groove without the swell, but when it is considered that the swell added 47 grains (806—759), to the weight, it is evident that the groove alone has a decided advantage over the other form. By the trials in unseasoned chestnut (Nos. 1 and 6) this advantage is 15 per cent. thus $\frac{2440-2121}{2121}=15.$ and by those on yellow pine (Nos. 2 and 7) it is $\frac{2328-2069}{2069}=12.5$ per cent.

In fact, after the ends of the fibres have once been thrust apart by the thick part of the swell it is evident that when they come opposite to the cavity, above the swell, they must lose some part of their power to press the spike and to produce the retaining force of friction. This force must then depend for its production on the action of those fibres of the wood which are opposite to the swelled portion, or between it and the points of the spike.

In the next series of experiments it was attempted to ascertain the relation between forms more diversified than had hitherto been employed.

As it is evident that the total retentiveness of the wood must depend, in a considerable degree, upon the number of fibres which are longitudinally compressed by the spike, it was inferred that on the area of the two faces which, in driving the spike, are placed against the ends of the fibres, must in a great measure, depend the retention of the spike. In this series four kinds of wood and ten forms of spikes were employed.

A comparison of the results, given in the following table, will show what order these *forms* would possess among themselves, in point of retentiveness as well as the advantages of the respective species of timber into which they were severally driven.

Table III.

Spikes of various forms—Timber of different kinds.

No. of the exp'nt.	Kind of spike used.	Kind and condition of the timber used.	Breadth of spikes.	Thickness of spike.	Area of two faces.	Depth to which driven.	Weight of the part inserted.	Force to extract the spike.	Ratio of force to weight of spike.	Date.	Remarks.
			inc.	inc.	sq in	inc.	gr's.	lbs.		1835	
1	Straight square.	Chest nut unseas oned	.405	.402	2.83	3.5	942	1995	2.116	Dec. 4.	
2	Burden's patent.	Do.	.373	.384	2.64	3.5	866	1873	2.162	Dec. 8.	
3	Broad flat.	Do.	.539	.288	.377	3.5	898	2394	2.663	Dec. 4.	
4	Narrow flat.	Do.	.390	.253	2.73	3.5	566	2223	3.927	Dec. 8.	
5	Straight square.	White oak thoroughly seasoned.	.405	.402	2.83	3.5	942	3990	4 129	Dec. 7.	
6	Broad flat.	Do.	.539	.288	3.77	3.5	898	5130	5.712	Do.	
7	Narrow flat.	Do.	.390	.253	2.73	3.5	566	3990	7.049	Do.	
8	Burden's patent.	Do.	.373	.384	2.64	3.5	866	3905	4.509	Do.	
9	Cylindrical with cutting edge.	Do.	diam .485			3.5	1211	3876	3.200	Do.	
10	Grooved and swelled.	Do.	.375	.375	2.60	3.5	806	3727	4.624	Do.	The measures in this and the two following cases, taken outside of flanches.
11	Grooved but not swelled.	Do.	.375	.375	2.60	3.5	759	4247	5.662	Do.	
12	Grooved and bottoms of grooves serrated.	Do.	.375	.375	2.60	2.5	500	2650	5 300	Do.	The weight of part inserted is given by estimation in this experiment.
13	Square.	Locust seasoned for 3 years.	.405	.402	2.83	3.5	942	5967	6.334	Dec. 8.	
14	Broad flat.	Do.	.539	.288	3.77	3.5	898	7040	7.839	Do.	
15	Narrow flat.	Do.	.390	.253	2.73	3.5	566	5273	9.316	Do.	

Table III.—(Continued.)

No. of the exp'nt.	Kind of spike used.	Kind and condition of the timber used.	Breadth of spikes.	Thickness of spike.	Area of two faces.	Depth to which driven.	Weight of the part inserted.	Force to extract the spike.	Ratio of force to weight of spike.	Date.	Remarks.
			inc.	inc.	sq in	inc.	gr's.	lbs.		1836	
16	Cylindrical pointed with 15 grooves filed longitudinally from the points upward.	Ash seasoned.	diam .500			3.5	929	2052	2.208	Jan. 4.	In this and the two following exp'nts the spikes were driven into the timber in the direction of the length of the fibres.
17	Do.	Do.	diam .500			3.5	929	2309	2.507	Do.	
18	Plain cylindrical pointed, scale not rem'd.	Do.	diam .500			3.5	1015	2451	2.414	Do.	

The above table furnishes three sets of comparisons for deducing the relative retentive powers of green chestnut, thoroughly seasoned oak, and equally seasoned locust. Thus the weight, which in those three cases drew the square spike from chestnut, was 1995 lbs. That which extracted the brood flat one, 2594, and that which drew the narrow flat one from the same timber, was 2223. The sum of these is 6612. The sum of the three numbers for the same three spikes used with oak, was, by experiments 5, 6, and 7, 13110: and the same of the three in locust, by experiments 13, 14, and 15 is 18280, these three numbers have to each other the relation of 1, 2, and $2\frac{3}{4}$, from which we infer that oak is almost precisely *twice*, and locust $2\frac{3}{4}$ times as tenacious as unseasoned chestnut. By comparing together the results of experiments 1 and 2, it will be seen that the weights required for extracting the two spikes respectively are more nearly proportional to the breadths than to either the thicknesses or the weights of the spikes, for the spike with a breadth of .405 inch, and a thickness of .402 required 1995 lbs. for its removal, while that which had a breadth of .375 inch, took 1873 lbs.

Now .373 : .405 : : 1873 : 2033 for the calculated retentiveness, instead of 1995 as given by experiment,—a difference of only + 38 lbs. between the observed and calculated results. Calculating the retention by the *weights* of the respective spikes, we should have 866 : 942 : : 1873 : 2037, or a difference of 42 lbs; while using the *thicknesses* alone, we obtain .384 . 402 : : 1873 : 1960, a difference of an opposite kind of 35 lbs. from the observed result. The greater thickness yielding the less retentive power. This correspondence between the breadths and the extracting weights, becomes still more apparent when we compare the *third* and especially the *fourth* with the *second* experiment. Thus for the broad flat spike (3d experiment) compared with experiment 2nd we have,

By breadths .373 : .539 : : 1873 : 2701 instead of 2394—diff. + 307
By weights .866 : .898 : : 1873 : 1942 - - " — 452
By thicknesses .384 : .288 : : 1873 : 1379 - - " — 1015

And for the thinner and lighter spike (experiment 5th) compared with No. 2. we have,

By breadths .373 : .390 : : 1873 : 1958 instead of 2223 observed, dif — 265
By weights .866 : .566 : : 1873 : 1224 - - " — 999
By thickness .384 : .253 : : 1873 : 1234 - - " — 989

Nearly the same conclusions would result from a comparison of those trials which were made on seasoned white oak and locust. Indeed it appears, that with a given breadth on the face of the spike, a diminution of thickness is sometimes a positive advantage to the retentiveness of the timber, for on white oak the spike which had a breadth of only .390, required as much force to extract it, as one of which the breadth was .405—though the thickness of the former was but .253, while that of the latter was .402, and on chestnut the thinner, narrower and lighter spike required absolutely more force to withdraw it, than the other. This leads us to notice the different kinds of action of the respective spikes on timbers of various kinds.

In the softer and more spongy kinds of wood the fibres instead of being forced back longitudinally and condensed upon themselves, are by driving a thick, and especially a rather obtusely pointed, spike, folded in masses backward and downward so as to leave, in certain parts only, the faces of the grain of the timber, in contact with the surface of the metal.

That the view just presented is correct, seems also probable from what was observed in the case of the swelled spike. For while the grooved but *unswelled* one driven into chestnut timber (Table II. Ex. 6,) required 1852 lbs. to extract it, the grooved and swelled one (Ex. 1. same table,) took but 1710. And in table III. Ex. 2, we find the swelled spike drawn from white oak by 3727 lbs., and the grooved but not swelled one (Ex. 12,) requiring 4247. Hence, it appears to be necessary in order to obtain the greatest effect, that the fibres of the wood should press the faces as nearly as possible in their longitudinal direction, and with equal intensities throughout the whole length of the spike.

Arranging the spikes according to the order of their ratios of *retention* to *weight*, as given by the experiments from 5 to 12, inclusive, in Table III., we have the following:

1.	Narrow flat, with a ratio of	7.049
2.	Wide flat, - -	5.712
3.	Grooved but not swelled, -	5.662
4.	Grooved and notched, -	5.300
5.	Grooved and swelled, - -	4.624
6.	Burden's patent, - -	4.509
7.	Square hammered spike, -	4.129
8.	Plain cylindrical, - -	3.290

Experiments 16, 17, and 18 of the same table were made by driving the spikes, which were cylindrical with conical points into the timber endwise of the grain. This method of comparing two forms, the one grooved, and the other plain, was adopted on account of the extreme liability of the timber to be split by driving spikes of these forms across the direction of the fibres. It was observed that on drawing these spikes the holes were almost perfectly square. This resulted from the position of the rings of annual growth, and the greater elasticity in some directions than in others. It is probable that, if the filed grooves, in experiments 16 and 17, had been

covered with a scale of oxide, as was the case with the plain spike used in experiment 18, the former would have given a somewhat higher result. When holes are drilled into stone blocks and afterwards plugged with timber to receive spikes, in fastening on the chairs of edge rails, the method of experimenting just described finds an application, and it is probable that in such cases the grooved cylinder, with a conical grooved point, may prove advantageous.

A few experiments were made to determine the effect of driving spikes to different depths on the total amount of retention. For this purpose two different spikes were selected, viz: the square hand-wrought spike, the section of which was .405 × .402, and the wide flat one, of which the section was .539 × .288. They were respectively driven to a certain depth into unseasoned chestnut—and then subjected to force just sufficient to start them,—this force was noted, the spike was then driven another inch and the force applied in like manner. All my experiments proved that when a spike is once started, the force required for its final extraction is much less than that which produced the first movement. This is readily accounted for, on the principle that a wedge shaped point was from half an inch to an inch in length, and as this on the starting back of the spike a very little distance, became mostly relieved from the pressure of the fibres, all that part of the retention, which had been due to the wedged shape portion was at once destroyed. The following table will show that the mere starting of the spike, with parallel faces, does not essentially diminish the retention when again driven into the timber to a greater depth than before.

But when a bar of iron is spiked upon wood, if the spike be driven down until the bar compresses the wood to a great degree, the recoil of the latter may become so great as to start back the spike a short distance after the last blow has been given. In this case a great diminution in the useful effect will be the consequence. This shows that a limit may exist to the force which we should apply in urging down spikes or bolts, especially those with large heads, destined to fasten materials together.

Table IV.

Spikes driven to different depths.

No. of experiment.	Form of spike.	Kind and condition of timber.	Breadth of Spike.	Thickness of spike	Area of the faces.	Depth to which the spike was driven.	Weight of the part inserted	Force to extract the spike.	Ratio of force to weight of spike.	Date.	Remarks.
			in.	in.	sq. in.	in.	grs.	lbs.		1835	
1	Square not filed.	Chestnut unseasoned.	.405	.402	.7695	1.9	483	1183	2.428	Dec. 4.	Retention / area of faces =770
2	Do.	Do.	Do.	Do.	1.1745	2.9	789	1995	2.528	Do.	Do. =850
3	Do.	Do.	Do.	Do.	.1579	3.9	1095	2565	2.342	Do.	Do. =795
4	Broad flat.	Do.	.539	.288	.9702	1.8	442	1525	3.457	Do.	Do. =785
5	Do.	Do.	Do.	Do.	1.5092	2.8	745	2594	3.482	Do.	Do. =865
											Mean 813

By comparing experiments 1 and 4 together it will be found that *weight for weight*, the flat spike had, when driven 1.8 inches, an advantage of 42.3 per cent. over the square one; and by like comparison of experiments 2 and 5, it is evident the former had a superiority of 37.7 per cent. As the spike when driven in only 1.9 inches had a much less proportion of its parallel faces and a greater proportion of the wedge shaped point, exposed to the reaction of the fibres, it is reasonable to expect that the retention would not correspond precisely with the lengths inserted. It will be understood that when we speak of cutting edges and the wedge shaped portion of spikes, whether square, flat, or cylindrical, the direction of the cutting edges is always across the fibre or grain of the timber. It must be evident that the wedge shaped part may be so acute as to correspond nearly with two parallel faces, in which case, the tendency to retreat from the lateral pressures is small, and the pressures themselves increasing from the point upwards to where the spike is thickest, the total efficiency of a given length may be as great as that of an equal length of the parallel faces, and even greater provided the thickness of the spike be so great as in driving it to produce much crushing and irregular folding of the fibres of the timber. If, on the contrary, the edge be very blunt, the tendency to recoil may be such as to diminish the adhesion and in this case the effect of the wedge shape is negative. In the other it may be positive.* The 1st, 2d, and 3d experiments indicate, in the 10th column of the preceding table, that beyond a certain limit the ratio of weight of metal to extracting force begins to diminish, showing that it would be more economical to increase the number rather that the length of spikes for producing a given effect in fastening materials together. In this case also it will be perceived that the adhesion has a much closer relation to the areas of the compressing faces of the spikes than to their weights. The 12th column shows that for three of the experiments this ratio may be regarded as *identical*, and the whole set goes to prove that the absolute retaining power of unseasoned chestnut on square or flat spikes of from two to four inches in length, is a little more than 800 lbs. for every square inch of their two faces which condense longitudinally the fibres of the timber.

The accompanying figures represent the appearances of timber as developed by splitting the specimens, through the axis of the cavities, left by the spikes when withdrawn.

Fig. 1—Is that presented by the locust timber, mentioned in Table II., Experiment 11, in which the weight required to extract the spike was 3990 lbs. The upper part of the figure exhibits the rising up of the timber just as the spike starts. In every case this effect was found, on examining the timber, to have been of very limited extent.

Fig. 2—Represents the grain of chestnut timber as affected in experiment 3, Table III, with the broad flat spike, and other trials. At the point of inflection downward the grain appears to be not only bent but often actually broken off.

Fig. 3—Exhibits the appearance of a specimen of hemlock timber, used in experiment with the straight grooved spike, (Fig. 4 of spikes) in which the weight required to extract it was but 1296 lbs.—See Table II, Experiment 8th.

* The following formula may represent the several experiments $R = lf \pm c$ in which R is the observed retention; l = the length in inches of the part inserted; f = the force of retention on one inch of the parallel sides; and c = the difference between the retention of a parallel portion of the spike and of an equal length of the converging faces near the point. The sign of ambiguity is due to the cause above stated.

1. 2. *Figures of Timber.* 3. 4.

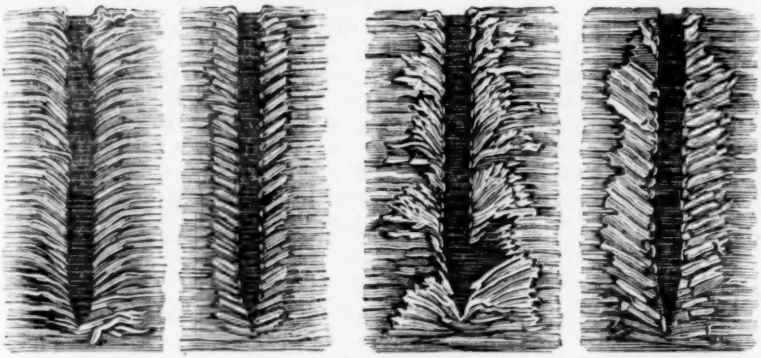


Fig. 4—Conveys an idea of the manner in which a defective specimen of pitch pine was affected by a spike. The force required to draw this spike was so trifling that it was not thought worth recording in the tables.

Figures of Spikes.

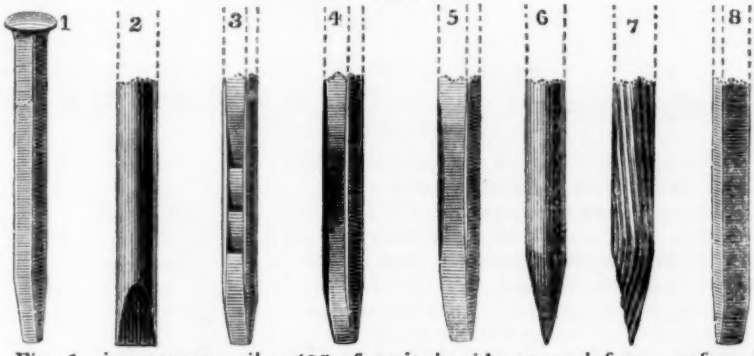


Fig. 1—is a square spike .405 of an inch wide on each face,—referred to in Table III, Experiments 1, 5, and 13.

Fig. 2—is a cylindrical spike .485 inch in diameter, sharpened to a cutting edge—see Table III, Experiment 9.

Fig. 3—is the grooved and notched spike, serrated in the bottoms of the grooves on the two faces, Table III, Experiment 12.

Fig. 4—is a spike with plain grooves on the faces, extending from the upper part of the bevel to the height of about $3\frac{1}{2}$ inches.

Fig. 5—is a grooved and swelled spike, that is, having the groove deeper at the distance of two inches from the point, than it is at one inch from it. At the former the depth of each groove is .066 inch.

Fig. 6—is a cylindrical spike .5 inch in diameter, tapered to a point.

Fig. 7—is a spike of the same diameter as the preceding, but having 15 spiral grooves proceeding from the point upward.

Fig. 8—is a flat spike .390 inch in breadth, and .253 inch in thickness. See Table III, Experiments 4, 7, and 15.

NOTE.—The only series of experiments, analogous to those above detailed, which has fallen under the notice of the writer was made in 1824*, by Mr. B.

* See Gill's Technical Repository, vol. V., p. 248.

Bevan, on the adhesion of sprigs, brads and nails, when driven into timber longitudinally and transversely. His operations were extended to several kinds of timber, viz:—Norway deal, dry oak, elm, dry beech and green sycamore.

He employed some nails of a very minute size of which 4560 were required to make a pound avoirdupois. One of these required 22 lbs. to extract it, when driven .4 of an inch into pine board. From this size he advanced by several gradations to the sixpenny wrought nail, of which 73 make a pound avoirdupois. Of the latter he drove one to the depth of one inch successively into pine, elm, dry oak, dry beech, and green sycamore, and found the forces required for its extraction to be as follows:

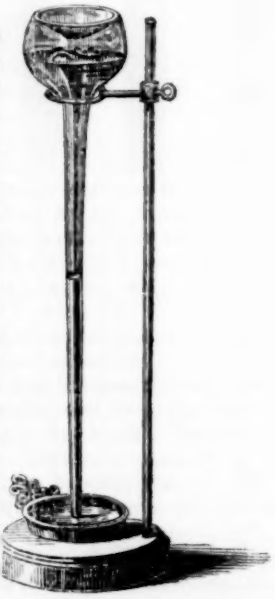
For Pine,	187 lbs.	Beech,	667
Elm,	327	Sycamore,	312
Oak,	507		

Mr. Bevan examined, to some extent, the difference between driving a nail by percussion with a hammer of known weight and range of fall, and forcing it into the wood by simple pressure. This curious inquiry did not, for obvious reasons, enter into the plan of the writer of this article. Mr. B. found that to force a sixpenny nail into pine 1 inch, it took a pressure of 235 lbs.; to extract it, 187; to force it in 1½ inch 400; to extract it 327;
" 2 inches 610; " 530.

Physical Science.

Culinary Paradox, or Ebullition by Cold. By R. Hare, M. D., &c., &c.*
Communicated by the author.

This figure illustrates a new and instructive method of effecting ebullition by cold.



The apparatus consists principally of a glass matrass, with a neck of about three feet in length, tapering to an orifice of about a quarter of an inch in diameter. The bulb is bulged inwards, in the part directly opposite the neck, so as to create a cavity capable of holding any matter which it may be desirable to have situated therein. In addition to the matrass, a receptacle, holding a few pounds of mercury, is requisite. The bulb of the matrass being rather less than half full of water, and this being heated to ebullition, the orifice should be closed by the finger, defended by a piece of gum-elastic, and depressed below the surface of the mercury; the whole being supported as represented in the figure. Under these circumstances, the mercury rises as the temperature of the water declines, indicating the consequent diminution of pressure within the bulb. Meanwhile, the decline of pressure lowering the boiling point of the water, the ebullition continues till the mercury rises in the neck nearly to the height of the mercury in the barometer.

* Republished from Trans. American Philos. Society, vol. V., N. S.

By introducing into the cup formed by the bulging of the bulb, cold water, alcohol, ether or ice, the refrigeration, the diminution of pressure, and the ebullition are all simultaneously accelerated, since these results are reciprocally dependent on each other.

The advantage of this apparatus and method of operating, lies first in the certainty and facility with which the apparatus is secured against the access of the atmosphere; and in the next place, in the index of the diminishing resistance, afforded by the rise of the mercurial column.

Hydro-Pneumatic Cistern. By the author of the preceding article.

In Silliman's Journal will be found an engraving and description of a pneumatic cistern, which I employed in the experimental illustrations of my lectures for more than ten years; and which I should probably continue to use now, had not the command of water from the public works, put it into my power to dispense with the mechanism for keeping the water at a proper level. As I am now situated, any deficit of water is easily supplied from the pipes known here as the hydrant pipes, by which the city is supplied with water; and any excess is carried off by a waste pipe. Many chemists designate as a pneumatic trough or tub, apparatus for the purposes to which that in question is applied. Neither of these names is, in my opinion, as applicable to the apparatus which I have hitherto used, as that of cistern, to which I resorted; and although the last term be less suitable to the apparatus which I am about to describe, yet I beg leave to adhere to it for want of a better appellation.

A A, Fig. 1. is a water-tight platform, surrounded by a wooden rim, R R R R, rising above it about an inch and a half. B, C, T, three wells or cavities, each in the form of a hollow parallelopiped, with all of which the cavity bounded by the rim communicates, so that when supplied with water to the level of the waste pipe, this liquid fills the wells, and covers the platform to the depth of about three-fourths of an inch.

E, F, G, shelves, which severally move in grooves over the wells, so that they may be placed in the most convenient position. Under H is a waste pipe. At I is the rod, which, when turned by the winch opens and shuts the orifice of the hydrant pipe. K, a pipe for emptying the wells and casks, with all of which it may be made to communicate when requisite by means of cocks. N, O, casks which act as gas holders, each having a communication with the cistern at Q or *q*, for letting in water from that source; the orifices being controlled by valves. By means of a pipe proceeding from its vertex, each gas holder communicates with a cock, at S or *s*, furnished with a gallows screw as represented in the figure.

To these gallows screws, flexible leaden pipes may be attached, for transferring gas either from one of the holders to a bell glass, or from a bell glass to one of the holders. When a communication is established between the cavities, either of these offices may be performed, accordingly as the pressure within the holder is made greater, or less, than that of the atmosphere. It will be greater when the valve for the admission of water is opened, that for letting it out being shut: and less when these circumstances are reversed.

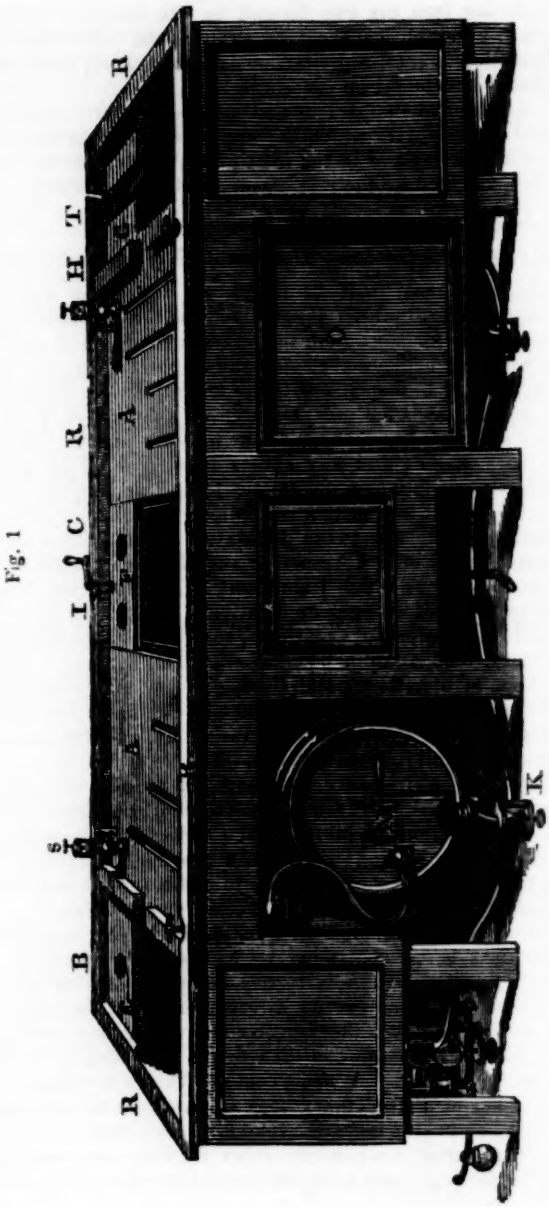


Fig. 1

Fig. 2 affords a view of the lower side of the sliding shelf, in the wood of which it will be seen that there are two excavations, converging into holes. This shelf is loaded with an ingot of lead at L, to prevent it from floating in the water of the cistern.

Fig. 2.

On the Cause of the Collapse of a Reservoir while apparently subjected within to great Pressure from a Head of Water. By the author of the preceding article.

In September, 1834, I was requested by Mr. Haydock, a respectable and intelligent plumber of this city, to call at his shop in order to see a copper reservoir, which had collapsed while apparently subjected to internal pressure, arising from a communication with the mains proceeding from the public water-works.

For the purpose of refrigerating the contents, the reservoir was placed in spring water, at the bottom of a well, so as to be at a small depth below the surface: receiving the river water by one pipe, it was made to deliver it by another.

The pressure of the water with which the city of Philadelphia is supplied, is known to be sufficient, when at its maximum, to command the most elevated rooms in our dwelling houses. Hence, had the reservoir been burst, it would not have excited surprise; but the converse appeared inexplicable. The figure annexed will convey a correct idea of the reservoir as it appeared when I examined it; or subsequently, when a drawing of it was made at the Franklin Institute, to which it had been removed, at the instance of some of the members of that institution.

A is a pipe with a stop cock to allow the air to escape on first filling the reservoir. B, a pipe by which a communication with the mains of the public water-works was established. C, a pipe for delivering the water.

The height of the vessel was three feet; greatest diameter eighteen inches, least diameter twelve inches.

Some days had elapsed, during which I was unable to offer any explanation of the phenomenon; but having mentioned the occurrence to another highly respectable and intelligent plumber, Mr. Ewing, he alleged that facts no less surprising had fallen within the range of his experience. He had known openings to be made in leaden pipes, and to be closed immediately afterwards; upon one occasion a small fish was caught in the fissure.

It then occurred to me that the phenomenon of the collapse had been the consequence of circumstances the inverse of those which are known to take place in the water ram

of Montgolfier, in which water, while flowing rapidly in a trunk, being stopped suddenly in front, is made to produce a jet rising above the level of the head to which the current arrested is indebted for existence.

The momentum of the water which is in that case expended in a jet, must, in the case in which an arrestation takes place in the rear of a given portion of the stream, continue to propel that portion directly forwards, causing an hiatus or vacuum between it and the valve or cock by which the stoppage has been effected.

The inward pressure, or suction, arising from such a momentum, was demonstrated by Venturi;* and has latterly been ingeniously applied to the filling of syphons, and the removal of back water from water wheels.

In this view of the subject then, we find the rationale of the collapse of the reservoir.

The current through the main being arrested at a point nearer the head than that from which the pipe supplying the reservoir proceeded, there was an hiatus produced within the main, and cavities therewith communicating, which caused the atmospheric pressure to be inadequately resisted, and consequently the reservoir, as one of those cavities, was crushed. No doubt the pressure of the spring water, in which the reservoir was situated, co-operated. At times our springs rise much nearer to the surface of the earth than at others.

When steam is made to pass through a pipe into cold water, a succession of expansions and condensations ensue, producing much noise and mechanical jarring, consequent to the alternate absorption and expulsion of the water. Agreeably to the rationale respecting the collapse of the reservoir, these effects should be productive successively of an inward and an outward pressure upon the surfaces of the pipes employed.

Some years ago, a leaden pipe of about an inch in bore was submitted to me by Mr. Ewing, which, while situated as above described, had been crushed by a force which seemed to have exceeded any which could, under any circumstances, be expected from the pressure of the atmosphere. Possibly an adhesion between the water and the metallic surface, may co-operate in the production of such results.

Analysis of Solar Light.

Within a few days past, notices have been circulated in the public prints, that Melloni had succeeded in depriving the sun's rays of all their heat, by transmitting them through certain media, consisting of water and coloured glasses; and also, that Mrs. Somerville, by means of a screen of pale green glass, had abstracted from them, that property by which they darken the chloride of silver, and effect chemical changes.

Whilst these results have been obtained in Europe, experiments of a like character have been carried on in Virginia, the event of which is of far more interest to chemists, the effects being equally as certain, and the means being in the hands of every experimenter. Dr. Draper, professor of chemistry in Hampden Sidney College, found during the last year, that there are several solutions, which are transparent as respects the sun's

* Nicholson's Journal, 4to series, vol. 2, page 172.

ligat, yet opaque to his calorific ray, and others which are transparent both to his light and heat, but opaque to the chemical ray; for it does not follow, that a body transparent to light should be transparent to heat or the chemical rays. A solution of sulphate of copper and ammonia, and a decoction of tannin are both transparent to the light of the sun, yet they are nearly opaque to his heat. Nor is this condition of things at all regulated by colour; the first mentioned of those substances which is blue, the second which is brown, and the sulphocyanate of iron which is red, the chloride of chromium which is green, the muriate of cobalt which is pink, and the bichromate of potassa which is orange, though they are all when in solution transparent to the rays of light, yet are either opaque or only translucent to the rays of heat. It has been found more recently, that solutions which are perfectly colourless and clear as water, exercise very different functions on the rays of heat, and though in an examination of upwards of two hundred and seventy such solutions, none have yet been found which are absolutely opaque to the rays of heat, there are some which approach that condition. Vegetable solutions, exercise a similar influence. Turnsole dissolved in water, when the thickness is about a quarter of an inch, permits only about four rays of heat, out of every hundred which fall upon it, to pass through: this is a blue solution; a decoction of Brazil wood which is red, a decoction of Logwood in alum which is purple, and tincture of turmeric which is yellow, have the same effect

A solution of the chromate of potassa is nearly opaque to the chemical ray, but is transparent to the ray of light, and more than semi-transparent to the ray of heat; the bichromate of potassa seems to be absolutely opaque to the chemical ray, for a beam of light three inches in diameter, conveyed to a focus by a convex lens, after traversing such a solution one-fourth of an inch thick, did not blacken chloride of silver in an exposure of fifteen minutes. All the vegetable solutions above named are likewise nearly opaque ; but a solution of the sulphate of copper and ammonia, when in a mass thick enough to stop almost all the rays of light, is freely permeated by the chemical rays. It is curious that several *yellow* metallic solutions, as the chloride of gold, the chloride of platinum, the permuriate of iron, and the hydrosulphate of lime, act about as powerfully as the chromate of potassa, but this peculiar tint is not always effectual in producing this result, for the yellow oil of turpentine, and the yellow ferrohydrocyanate of potassa, fail to prevent the blackening of the chloride.

These experiments therefore decide the question of the separate existence of calorific and chemical rays in solar light; they also enable the philosophic chemist to insulate each ingredient and operate upon it by itself, a matter of the utmost importance in the investigation of the properties of light.

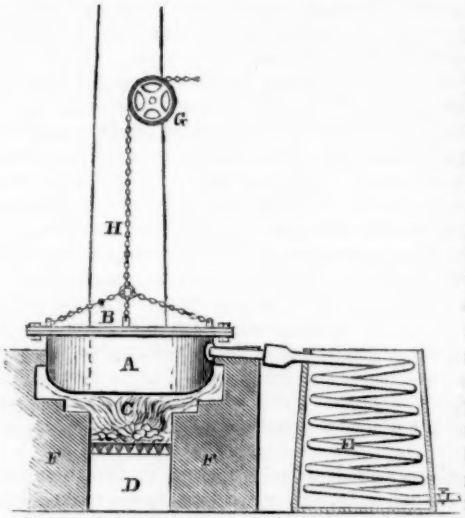
Progress of Practical and Theoretical Mechanics and Chemistry.

A Solvent not hitherto used in the Arts.

A patent was granted to William Henry Barnard, of the city of London, for his invention of "a solvent not hitherto used in the arts."—[Sealed 20th August, 1833.]

My invention consists in an essential oil or liquid, which I obtain by the distillation of a well-known article of commerce, imported into this country from Para, Valparaiso, Sincapore, and other places, under the title of

caoutchouc, or India rubber, which is to be performed in the following manner:—



I take a mass of the said caoutchouc, or India rubber, as imported, and having cut it into small lumps, containing about two cubic inches each (which I prefer,) I throw these lumps into a cast-iron still (which I find adapted to the purpose, and a diagram of which is annexed to, and forms part of, this my specification,) with a worm attached, as in the figure: A, is the still; B, the cover ground to a metallic fit, and held down with cramps and set screws; through the cover there is a hole with a plug ground to fit, to admit of a thermometer to take the temperature; C, the fire-place; D, ash-pit; E, the worm-tub; F, the brick-work of still; G, a roller and carriage, in conjunction with a crane, or other means, to raise the cover to take out the residue, and to charge the same; H, the chain.

I then apply heat to the still in the usual manner, which heat is increased until the thermometer ranges at 600 degrees of Fahrenheit, or thereabout. And as the thermometer ranges progressively upwards to 600 degrees Fahrenheit, a dark-coloured oil or liquid is distilled over, which I claim as my said invention; such liquid being a solvent of caoutchouc, and other resinous and oleaginous substances. When the thermometer reaches 600 degrees, or thereabout, nothing is left in the still but dirt and charcoal.

I have found the operation of distillation to be facilitated by the addition of a portion of this oil, either previous or subsequent to rectification, as hereinafter mentioned, in the proportion of one-third oil to two-thirds caoutchouc, or thereabout.

I afterwards subject the dark-coloured liquid thus distilled over to the ordinary process of rectification, and thereby obtain fluids, varying in specific gravity, of which the lightest hitherto has not been under .670 taking distilled water at 1,000; which fluids I also claim as my said invention.

At each rectification the colour of the liquid becomes more bright and transparent, until at the specific gravity of .680, or thereabout, it is colourless and highly volatile.

In the process of rectification (for the purpose of obtaining a larger product of the oil colourless,) I put about one-third water into the still. In each and every state the liquid is a solvent of caoutchouc, and several resinous and oleaginous substances, and also of other substances (such as copal,) in combination with very strong alcohol.

Having experienced much difficulty in removing the dirt which adheres to the bottom of the still, I throw into the still lead and tin in a state of alloy (commonly called solder,) to the depth of about half an inch; and as this

becomes fused, the dirt which lies on the surface of it is more easily removed.

Objections having been made to the smell of this liquid, I have found such smell removed by mixing and shaking up the liquid with nitro-muriatic acid, or chlorine, in the proportion of a quarter of a pint of the acid (of the usual commercial strength) to a gallon of the liquid.

And whereas I claim as my invention, the said solvent or liquid when first distilled over, and in each and every stage of its rectification.

The discovery of the chemical solvent, which forms the subject of the patent above described, has excited considerable interest in the philosophic world, not only from its extensive usefulness as a new article of commerce, but also from two very extraordinary characteristics which it is found to possess; viz., that in a liquid state it has less specific gravity than any other liquid known to chemists, being considerably lighter than sulphuric æther, and in a state of vapour is heavier than the most ponderous of the gases.

The properties of this singular production are yet but in a small degree developed. Dr. Faraday, of the Royal Institution, and Dr. Hue, of St. Bartholomew's Hospital, have both directed their attention to the subject, and have given to the solvent the denomination of *caoutchoucine*, as the distilled product of *caoutchouc*, the elastic gum, known under the common name of India rubber.

This elastic gum is produced by a variety of trees, and is found in all countries at or near the Tropics. The Heavea Caoutchouc (whence the name) grows in South America; the Urceola Elastica in Sumatra; the Ficus Elastica and Ficus Indica (Banyan) in various parts of the East Indies; the Artocarpus Incisa (bread fruit-tree) in the West Indies—we have it also from Africa, but from a variety of trees. Those above enumerated are clearly of totally different descriptions, some growing as climbing plants, some as forest trees. These trees yield the fluid in immense quantities; it is said, in some instances, as much as two-thirds the weight of the boughs whence it is drawn, and when exhausted by repeated tappings, renew the supply after a few months' rest.

Dr. Faraday stated the component parts of a quantity of the fluid he had analysed to be as follows:—

Caoutchouc - - -	,317.0
Albuminous matter - -	19 0
Azotic, bitter colouring matter -	70.0
Wax - - -	1.3
Soluble substance - -	29 0
Water, acid, &c. - -	,563.7
	1000.0

Its elements—

Carbon -	6.812	8 proportions.
Hydrogen -	1.000	7 proportions.

There is not a particle of oxygen in the fluid after distillation, when in its most highly-rectified form, and it is capable of preserving potassium. It mixes readily with pure alcohol, but refuses to do so as soon as its specific gravity increases. We do not know at what exact weight a separation takes place, but imagine, from reported experiments, that at a specific gravity of 0.75, it will no longer unite with alcohol. This fluid is obtained at all the

intermediate gravities between 0.68 and 0.88. Perhaps if these operations were conducted with very great nicety, and the caoutchouc could be procured, divested of all foreign matter and impurities, water, &c., we should obtain by distillation the precise weight of fluid for the weight of solid operated on.

The speedy evaporation of the caoutchoucine, of course, produces intense cold; it has been found to reduce the thermometer 10 degrees below zero of Fahr., from 60 degrees above, in a minute and a quarter. At about 10 degrees above zero, a very remarkable concretion takes place resembling snow on the bulb of the thermometer, termed by Dr. Faraday the Bicarburet of Hydrogen; and it is believed that this is one of the new products alluded to, as discovered by Professor Mitscherlich.

Dr. Ure first exhibited this experiment, which may easily be repeated, by tying round the bulb of the thermometer a piece of thin muslin, and blowing upon it with a pair of bellows while the fluid is dropped upon it.

If a current of hydrogen gas be made to pass through the highly-rectified liquid, it will carry up with it a considerable portion, and become an illuminating gas of great brilliancy and beauty. This experiment was tried by Dr. Hue at the Hospital Laboratory; and the combination of the two vapours remained perfect several days, though the application of greater cold might have caused them to separate.

If the hydrogen gas and the highly-rectified fluid could be *cheaply* procured, a most excellent portable light would be the result; but the expense of both is at present a bar to such a plan.

This new material is a solvent for all the resinous gums, and particularly for gum copal, which it dissolves without artificial heat, at the ordinary temperature of the atmosphere: a property possessed by no other solvent known; and hence it is particularly useful for making varnishes in general. It also mixes readily with oils, and will be found to be a valuable and cheap menstruum for liquefying oil-paints; and, without in the slightest degree effecting the most delicate colours, will, from its ready evaporation, cause the paint to dry almost instantly.

Cocoa-nut oil, at the common temperature of the atmosphere, always assumes a concrete form; but a portion of this caoutchoucine mixed with it will cause the oil to become fluid, and to retain sufficient fluidity to burn in a common lamp with extraordinary brilliancy.

The importance and singularity of this new material has induced Dr. Faraday to bring it under the notice of the members of the Royal Institution, before whom, in a very interesting lecture, he explained and exhibited many of its properties; and we cannot better close our observations on this subject, than by giving a report of the Doctor's lecture.

The lecturer commenced by describing the process adopted by the Patentee for decomposing caoutchouc, and converting it into the new spirit or material denominated caoutchoucine; and observed that, those who are not acquainted with the very extensive works erected by Messrs. Enderby and Company, at Greenwich, in whom the patent right is vested, it may be interesting to know, that the preparation and manufacture of the New Zealand flax, for the production of ropes and cordage, has been a principal object of their exertions; and that in prosecuting this manufacture, in which they have spared neither talent nor expense, in order to render the ropes impervious to water, and preserve them from the destructive effects of damp by saturating the fibres in a solution of India rubber, they have been led to the discovery which formed the chief subject of the lecture.

The great urbanity and freedom with which Messrs. Enderby have shown this establishment to their numerous scientific visiters, is a feature so different from the usual calculating secrecy of mercantile houses, that we deem it right to notice the circumstance as an omen of a more enlightened age, wherein all shall be willing to impart those seeds of knowledge and of truth, which, while they do not injure the parent tree, become the prolific source of benefit to the public at large.

After exhibiting living specimens of the plant from which the caoutchouc is manufactured, of the sap, which appeared like cream, and of the various forms in which the India rubber is imported, the Doctor alluded to its first introduction into commerce about 70 years ago, when it was sold by Mr. Nairne, the mathematical instrument maker, of Cornhill, in cubical pieces of about half an inch square at 3*s.* each, which he recommended as a convenient means of destroying the traces of black lead pencils; whence it derived the name of India rubber, which it still retains.

Such a limited application of caoutchouc continued until within a very few years of the present time; but latterly it has been found available to a multitude of purposes connected with manufactures and the mechanical arts, so much so, that we learn the quantity now imported into this country exceeds the enormous sum of 200 tons per annum.*

Messrs. Enderby have at this time more than 100 tons actually in process of operation at their manufactory, where it is used, when melted with tar, for dressing or paying, as it is called, the ropes and cordage, manufactured by them from the New Zealand flax, and also for the distillation of the caoutchoucine spirit above alluded to, which is coming largely into use for the various purposes stated.

In the production of light, about one quarter of the caoutchoucine dissolves the cocoa-nut oil, and forms an excellent fuel for lamps; one of which (a French Argand) was exhibited on the lecture table, and burnt with peculiar brilliancy. Dr. Faraday then alluded to another application of this spirit to the lamps invented by Mr. Beale, who was present, and exhibited their action. This lamp, which has been made the subject of a patent, we shall probably describe in our next.

After briefly adverting to the various important applications of caoutchouc by Messrs. Mac Intosh, Hancock, and others, to articles of domestic and surgical clothing, beautiful specimens of which were exhibited, Dr. Faraday proceeded to the more immediate object of the lecture; and in speaking of the composition of caoutchouc, particularly adverted to the extraordinary quantity of carbon contained in it; namely, 68 of carbon to 10 of hydrogen: forming what is termed a hydro-carbon. The lecturer then placed a very small quantity of the cream-like sap in a capsule over a spirit lamp, by which the caoutchouc was coagulated into a solid substance, and appeared in surprising quantity, more especially as the sap had already deposited an immense quantity of solid caoutchouc in the bottle from which that small

* Previous to October, 1832, the duty levied upon elastic gum (as it was called) was 5*l.* per lb., or nearly 50*l.* per ton. Its extensive introduction was thereby entirely precluded. The Legislature have, subsequent to that period, reduced the duty to 1*l.* per ton; hence its increased importation and consumption, which is still greatly increasing.

The supply of this material is inexhaustible; the banks of the River Amazon, as reported by Messrs. Enderby's agents sent out expressly for that purpose, are covered with forests of trees producing it in large quantities, and from Java alone the world might be supplied.

quantity was poured. Dr. Faraday then remarked as an extraordinary fact, that the composition of the caoutchouc did not seem altered, although its properties are completely changed when, by melting, it is converted into a viscid matter incapable of again coagulating; and when by a still higher heat it is distilled over into the spirit termed caoutchoucine (10 parts of which are obtained from 12 of solid caoutchouc, and when rectified has a specific gravity of .680, being lighter than ether, and presenting a most remarkable instance of the quantity of solid matter that can be suspended in a liquid form.)

What is most extraordinary in the opinion of the Doctor is, that this very liquid is itself a solvent for caoutchouc in a natural state, and deposits it on evaporation unaltered, affording a grand desideratum in the arts, and promising a most abundant source of useful manufactures.

Caoutchoucine is extremely volatile; and yet its vapour is so exceedingly heavy, that it may be poured, without the liquor, from one vessel to another like water. A portion of the vapour was poured into an open glass vessel, which, of course, seemed to contain nothing, and yet, when carried towards a lamp, placed at the extremity of the lecture table, and then inverted, or rather the vapour poured out into the flame of the lamp, when it immediately inflamed, and thus most satisfactorily establishing its presence in the open glass vessel; and consequently its weight, which had prevented its escape though the vessel had been removed, affording a most satisfactory proof of these facts, and of amusement to the spectators generally.

Lon. Jour. Arts and Sciences.

Improved method of Blasting Rocks.

(From Evidence of John Taylor, Esq., before the Select Committee of the House of Commons on Accidents in Mines.)

Have any improvements been recently made in the mode of applying gunpowder to blasting in Cornwall?—Yes; I think two or three important ones.

Have the goodness to describe the former practice and the present?—The blowing rock by gunpowder is a simple process; the hole is bored into the rock, and in such direction as to expose the weakest part to the action of the powder; this hole is charged with a certain portion of gunpowder, and is then filled by clay, or more usually with a soft kind of rock, which is rammed into it, leaving a small orifice through which the rush or fuze is afterwards introduced for setting fire to it. The most dangerous part of this process is the ramming in of this soft rock to confine the powder, which is technically called tamping; this used to be done with an iron bar; that bar striking siliceous portions of the rock, inflamed the powder, and the men were injured, perhaps killed. The first improvement was making that bar of copper, or a part of it of copper; still the needle or small rod which is introduced in the tamping, to preserve the orifice for blasting, was of iron, and that sometimes inflamed the gunpowder: some years ago we substituted copper instead of iron, and in doing so had very great difficulty with the men; it was one of the strangest things possible to see the masters and the agents taking all possible pains to preserve men's lives, and to find the men so reckless, that though those copper needles were given to them at the same cost only as the iron ones, they would not for a long time use them. I believe we prevailed at last by depriving all the men who were injured in that way of the relief which is usually given from a fund raised in the

mine; and I believe that was more effectual than any thing else that was attempted, though we tried fines and many other expedients. The copper needle is now generally used, which is the second improvement that has been introduced; but I think the last improvement is one of the best; it is the invention of a person in Cornwall, who has made what he calls safety-fuzes; instead of the usual practice of filling a rush or tube with powder and dropping it into the hole, this person has invented a cord, in which is introduced a thin vein of gunpowder, and is covered with tar or pitch; and the safety this gives is owing to a certain length burning in a certain time. Accidents took place frequently to the man who had to fire the hole; for instance in sinking at the bottom of the shaft, the workman has to fire the hole, and then to be drawn up by a single rope over it; if the fuze communicate to the gunpowder more rapidly than he expects, he is blown to pieces; but with the safety-fuze he may take two feet or three feet, and so delay the explosion that he may be sure to be in a place of safety before it happens. This is made so cheaply, that no difficulty has been found in its introduction; the men are supplied with it, so that it is not worth their while to make the common fuzes, and I think it is one of the most happy thoughts that has occurred. Lon. Mech. Mag.

Coating which prevents the Formation of tuberculous excrescences in cast-iron pipes used as conduits for water.

The cast iron pipes which convey water to the city of Grenoble, became so obstructed by the formation of concretions of oxide of iron as to lessen the discharge of water to nearly one half in the course of seven years. This diminished diameter of the pipes appeared to remain afterwards, and for a considerable time, stationary, but as no dependence could be placed upon this cessation of the cause of obstruction, it became a matter of great importance to devise the means of preventing its further progress.

M. M. Gruymard and Vicat, engineers en chef, propose an interior coating of hydraulic lime. Two years trial have satisfied them that hydraulic mortar of a suitable consistency and applied to the thickness of about $\frac{1}{10}$ of an inch is, of all easy applications, the cheapest and best. It adheres readily to cast iron and prevents all oxidation and consequent production of tubercules. When the pipes are long, the mortar is applied with a maulkin or swab. Jour. de Pharm.

Note on Radiant Heat. By H. F. Talbot, Esq., F. R. S.

M. Melloni says (in the Number of this Journal for December last, vol. vii. p. 475,) that

"For a long time the immediate transmission of terrestrial radiant heat by transparent substances, both solid and liquid, has been denied; and the opinion has become prevalent that we see in experiments of this kind only an effect of the heat absorbed by the body submitted to the calorific radiation."

This "prevalent opinion" he has shown to be erroneous, but by experiments which are too delicate to be repeated with facility.

As a popular illustration of the fact, therefore, seems to be wanted, I subjoin the following rude but convincing experiment.

Let a poker be heated bright red hot, and having thrown open a window, approach the poker quickly to the *outside* of a pane, and the hand to the

inside. A strong heat is felt at the instant, which ceases as soon as the poker is withdrawn, and may be again renewed, and made to cease as quickly as before. Now, every body knows that if a piece of glass is so much warmed as to convey this impression of heat to the hand, it will retain some part of that heat for a minute or more; but in this experiment the heat vanishes in a moment. It is not, therefore, heated glass which we feel, but heat which has come through the glass, in a free or radiant state.

L. & E. Phil. Mag. March.

Wilkinson's Alarm.

This alarm consists of a percussion lock of a very strong and durable construction, fixed upon a stout post, from which wires were led in various directions over the grounds to be protected, in the same way as the wires of spring-guns used to be. The lock is made to communicate with a rocket or a maroon, or with both. In the event of any of the wires being touched, the lock is discharged, and striking a percussion cap, ignites the maroon, the audible report of which alarms the persons who are on the look-out; a rocket at the same instant ascends, and remains stationary for five or ten minutes over the spot, throwing down a vivid light, which indicates the situation, and exhibits the progress of the depredators.

Mr. Wilkinson's alarm has been very extensively employed by noblemen and gentlemen for the protection of their property from midnight marauders, and it is the best contrivance for the purpose I ever met with. These alarms are in every way infinitely superior to the inhuman "man-traps and spring-guns," even were they still legal; they are properly described as "being perfectly free from danger to servants or others having care of them; but calculated when they go off to strike terror into the breast of the most audacious depredator."

Mech. Mag.

On Decrepitation.

M. Baudrimont observes that authors have generally attributed the phænomena of decrepitation to the presence and sudden vaporization of water, or to the sudden production of aëriform matter. It is remarkable, he observes, however, that the greater number of bodies which decrepitate are really anhydrous and fixed; such are sulphate of potash, sulphate of barytes, chloride of sodium, &c. In order to explain this anomaly it is supposed that these substances contain water interposed between their constituent parts. M. Baudrimont found, however, that after drying several fixed and anhydrous bodies in several ways, at a low temperature, as completely as possible, they still decrepitated when quickly heated; he also observed that the slaty clays mixed with coal decrepitated strongly when thrown into a hot furnace, and that those which presented most surface decrepitated the loudest. Slaty clay possesses a well-marked lamellar structure; and it was found that anhydrous bodies susceptible of decrepitating did not undergo it, except they were crystallized and possessed a smooth easy cleavage. This disposition to divide evenly on large surfaces offers a ready explanation of their decrepitation. In fact, substances which decrepitate, being such as are considered bad conductors of heat,—and their external parts are the first heated,—the dilatation which they suffer forces them to separate from the neighbouring parts which have not yet acquired the same temperature, and this is facilitated by their property of cleaving.

There are substances which may decompose and yield volatile products when heated, and in this case it is difficult to say whether it is to an unequal dilatation of their parts or to the repulsive action of these volatile products that the decrepitation is to be attributed. However, as they possess, almost all, a crystalline structure or an easy cleavage, this structure is probably often the only cause, for they decrepitate actually without having suffered the least apparent decomposition, as the cyanide of mercury and emetic tartar. Substances which do not possess a crystalline structure, may decrepitate when they have not been perfectly dried; such are plastic clays and argillaceous schist.

From what has been stated, decrepitating substances may be divided into two classes, viz. fixed bodies, and those which yield aëriform products. Among the first are sulphate of barytes, sulphate of strontian, sulphate of potash, chromate of potash, bichromate of potash, fluoride of calcium, chloride of sodium, chloride of potassium, bromide of sodium, bromide of potassium, iodide of potassium, and galena. Of the bodies which decompose and yield aëriform products at a high temperature, some are anhydrous, as nitrate of barytes, nitrate of lead, rhombic carbonate of lime, and cyanide of mercury. Others are hydrates, as tartar emetic, lamellar sulphate of lime, acetate of copper, bitartrate of potash, and ferrocyanide of potassium.

Those substances which contain a large quantity of water in a state of combination do not really decrepitate, unless they are susceptible of cleavage: such are the carbonate of soda, sulphate of soda, sulphate of magnesia, &c.

Cleavage therefore is as essential a condition of decrepitation as water or its elements. Lon. & Ed. Phil. Mag.

Progress of Physical Science.

Temperature of the Globe.

M. Poisson, in his elaborate work entitled *Mathematical Theory of Heat*, has broached some new notions in respect to the source of the earth's heat. He observes, that the spherical form of the earth, and its flattening at the poles, prove that it was originally in a fluid, or perhaps in a gaseous state. After this period, it can only have become solid, either wholly or in part, by a loss of heat, proceeding from the circumstance that its temperature exceeded that of the medium in which it was placed. He conceives, that it has not been demonstrated that the solidification commenced at the surface, and gradually extended to the centre, as those theorists assert who adopt the idea of a fluid centre. The contrary appears to Poisson more probable: those portions nearest the surface having been cooled first, have descended into the interior, and been re-placed by matter from the interior, which has again descended in its turn, and thus the process was repeated until the whole mass was cooled down. But further, the central layers would become solid, in consequence of the immense superincumbent pressure at a temperature equal to, or even superior to that of the layers nearer the surface. Experiment has proved that water at common temperatures, when submitted to a pressure of 1000 atmospheres, undergoes a condensation of about $\frac{1}{20}$ of its original volume. Now, if we conceive a column of water equal in height to the earth's radius, and reduce its weight to one half of what it possesses at the surface, in order to render it equal to the mean gravity of each radius of the earth, supposing the latter homogeneous, the

inferior layers of this liquid column will undergo a pressure of above three millions of atmospheres, or equal to above three millions of times that which reduced the water $\frac{1}{20}$ of its volume. Without any knowledge of the laws of the compression of this liquid, we must still believe, that such an enormous pressure would reduce the inferior layers of the mass of water to the solid state, even when the temperature was very high.

In order to explain the elevation of temperature which we observe in proceeding from the surface towards the centre of the earth, he suggests the effect of the inequality of the temperature of the regions of space, which the earth successively traverses, because he considers it very improbable, that the temperature of space is every where the same. The mean temperature of space, may be admitted to differ little from zero, in place of being, as has been generally calculated below the temperature of the coldest regions of the globe. The variations in the temperature of space may, however, be very considerable, and they ought to produce corresponding variations in that of the earth, which will extend to depths dependent on their extent and degree. "If we suppose for example, a block of stone to be carried from the equator to our latitudes, its cooling will have commenced at the surface and extended into the interior, and if it has not reached the whole mass because the period has been insufficient, this body when it has arrived in our climate will present the phenomenon of a temperature increasing from the surface. The earth is in the condition of this block of stone; it is a body which proceeds from a region whose temperature was superior to that of its present situation; or, if we wish, it is a thermometer, moveable in space, which has not time, in consequence of its great dimensions and its degree of conductibility, to take in through its whole mass the temperature of the different regions which it traverses. At present, the temperature of the globe increases below its surface. The contrary has already, and will again take place. At other periods, besides at epochs separated by numerous ages, this temperature ought to be, and will be, by consequence, much higher or much lower than it is now, which prevents the earth from being always habitable by the human species, and has, perhaps, contributed to the successive revolutions of which its external layer has preserved the traces."*

Rec. Gen. Science.

On the Aurora Borealis. By Mr. Herapath.

This gentleman, whose name is familiar to men of Science, infers, from the appearance of an aurora on the 18th of November last, which exhibited its streamers on the upper edge of a heavy and well defined cloud in the north western horizon, that there is a very strong probability that aurora is merely *electricity passing off from a charged cloud, in the act of dissolving in air, that can take its water, but not its electrical fluid*, which fluid, while dispersing through a rare atmosphere becomes evident to the eye.

The objection to this theory which arises from the calculation of the height of the aurora which place the regions of the phenomena far beyond the limits of our atmosphere, the author thinks is unworthy of confidence from the entire uncertainty of the identity of the phenomenon noticed by each observer, when angles of elevation are taken at the same time. If each observer sees a different cloud, as he thinks is the fact, it is obvious that no reliance can be placed on the calculated heights.

* Bibliotheque Universelle, June, 1835. Ann. de Chimie, lix. 71.

If his hypothesis is correct, he says it will follow:

That the aurora will never be seen in foggy weather, nor in a damp state of the air, unless the state of the atmosphere above the cloud is much drier than that near the surface of the earth.

That it will most probably occur when a detached electrical cloud is in the lower, and a dry and similarly electrified stratum of air in the upper regions.

That, as the northern winds of this island are the driest, so it must be in that quarter that the aurora will most be seen.

That it will rarely be visible to a spectator who is northward of the cloud, or under it, as the mass of the cloud will intercept his view; that it will not appear in the day, or in a bright moon-light, because it would be overpowered by a superior light.

That the magnetic needle should be disturbed during the aurora, as free electricity is diffusing itself.

As it will require more observations to confirm or refute this hypothesis, he hopes meteorologists will direct their attention to it; and remarks that he has twice since had an opportunity of witnessing an inferior display, and that appearances were in strict conformity to the principles here laid down.

G.

Br. Naut. Mag.

Electric spark obtained from the Torpedo.

The attempts which Dr. Davy made to obtain a spark from the torpedo were not attended with success. M. Matteucci has, however, been fortunately successful in his trials. He employed for this purpose an apparatus perfectly similar to that employed by Mr. Faraday for obtaining a spark by means of a single voltaic pair. The principle object of this arrangement is to prevent the electricities from being neutralized directly by the medium of the conducting body which developes them, and of forcing them to unite exteriorly across the thin layer of air where the spark is produced. Matteucci has also succeeded in magnetizing steel needles in the same manner.* In a letter from Matteucci, read by Donne before the Institute, we learn that an electrical discharge may be obtained from the torpedo, although the skin of the organ be removed, and, even when portions of the substance of the electrical apparatus have been cut away. When the torpedo does not discharge electricity, it is impossible to obtain, even in the interior of the organ, the least trace of electricity in any point whatever, either with the galvanometer or condenser. The intensity of the shock is reduced by diminishing the number of nervous filaments which go to the organ. In the act of discharging, the electrical current always passes from the back to the belly. Three grains of muriate of morphin introduced into the stomach of a torpedo killed it in ten minutes; its death is accompanied with stronger shocks than usual, and with convulsions. When the torpedo has ceased to give electrical shocks, even when irritated, if we lay bare the brain, and touch gently the posterior lobe of the brain which gives nerves to the electrical organ, stronger shocks than usual (3 or 4) are produced, but having the same direction from the back to the belly. If, in place of simply touching the surface of the brain, it is wounded without taking the same precaution, then very strong shocks are renewed, but without having the same constancy in the direction of the current. These facts, and especially the

* Bibliotheque Universelle, June, 1836.

latter, are sufficient to show, Matteucci thinks, that the electricity of the torpedo is not produced in the organs situated on each side of the animal; that the current receives its direction from the brain, and that in the electrical apparatus, the electricity is only condensed as in the Leyden jar.

Rec. Gen. Science.

Earthquake at Anchor.

The following notes, made on board H. M. S. Volage, while at anchor in Callao Roads, during the severe earthquake which occurred in March, 1828, are of considerable interest. We understand, that part of the chain cable of the Volage which was exposed to its effects, from being then in use, is now in the possession of that learned gentleman, Mr. Faraday.

March 30, 1828. The morning clear, and a light breeze from the southward. At 7h. 28m. a black thin cloud passed over the ship, with very heavy distant thunder. At the same moment we felt the shock of a severe earthquake. I should think it continued seventy or eighty seconds. The ship trembled violently, and the only thing I can compare it to is, the ship being placed on trucks, and driven with rapidity over coarse paved ground. The ship was moored with two chain-cables, and on weighing the anchors a few days after, we found 56 links of the best bower cable much injured; the iron had the appearance of being melted, and nearly one-sixth of the link was destroyed. This piece was 30 fathoms from the anchor, and 20 fathoms from the ship. The bottom was soft mud, in which the cable was buried. During the earthquake the water alongside was full of little bubbles; the breaking of them sounded like red-hot iron put into water. The city of Lima suffered considerably, and a number of lives were lost. This severe shock was felt for nearly one hundred miles north and south of Lima. Br. Naut. Mag.

Presence of Iodine in various minerals, and in plants which grow remote from the Sea.

Iodine was first discovered in the ashes of sea weed; afterwards in sponge and in the waters of some mineral springs. This singular substance seemed therefore to be justly ranked among marine productions, when, to the astonishment of chemists, Vauquelin detected it in considerable portion in a specimen of an Argentiferous mineral which had been sent him from Mexico. No one knew, however, from what locality this mineral was derived.

Recollecting these circumstances, M. Arago announced to the Academy, that having fallen in company with some young officers of the corps of engineers which the Mexican government had just sent to Paris to continue their studies, it came into his mind to speak of Vauquelin's discovery, but without any expectation whatever, that these young *militaires* could supply the information which was wanting with respect to the locality of the mineral in question. We may imagine how agreeably he was surprised in receiving from Captain Yniestra a note, of which the following is nearly a literal translation.

"At the time when Vauquelin discovered Iodine in a silver ore, from Mexico, M. del Rio, professor of mineralogy at our School of Mines, proved the presence of the same substance in the pure silver of Albarradon. This is the name of a district contiguous to that of Mazapil in the department of Zacatacas. Temeroso is the name of the mountain of Albarradon, where the silver mines are situated.

"Our noted Bustamente has also found Iodine in the white lead of the mine of Catorce, situated in the department of Guanajuato. In 1834, in company with Mr. Herrera, I made myself a quantitative analysis of this last mentioned mineral. I will give you the results when my trunk arrives.

"I know not whether you have been informed, that in Mexico, Iodine has been discovered in the Sabila and the Romeritos. The Sabila is a plant of the genus maguey (*agaves*) which grows on the plains and on the sides of mountains. The Romeritos is a kind of varilla which vegetates on the floating gardens of the fresh water lakes in the neighbourhood of the Capital, it is much eaten during lent."

Annales de Chemie.

Analysis of Virginia Snake Root. (Polygala Senega.) By T. A. Quevenne.

This account occupies 30 pages of the *Journal de Pharmacie*, and appears to contain a much more thorough examination of the Virginia Seneca Snake Root than any to which it has hitherto been subjected. The substances which the author discovers in the Polygala, are Polygalic acid, Virginaic acid, pectic acid, tannic acid, yellow colouring matter, gum, albumine, cerine, fixed oil, carbonate of lime, carbonate of potash, sulphate of potash, phosphate of potash, chloride of potassium, sulphate of lime, phosphate of lime, alumine, magnesia, silex, and iron.

From the whole scope of the examination he is led to the following conclusions:

1. That no alcaline principle exists in the Polygala of Virginia.
2. That the therapeutic action of the root is owing to a principle that had not before been obtained in a state of purity, and which he finds to possess acid properties.
3. That this acid, which he designates Polygalic acid, being sufficiently distinct in its character, ought to assume a place in that class of bodies.
4. That the Polygalic acid exists in a free state in the root.
5. That there is, also, in very small quantity, in the Polygala, a volatile fat acid, analogous to the valericinic and phocenic acids; this he denominates Virginaic acid, and to this he ascribes the odour of the root.
6. That, in order to extract the active principle of the Polygala, the best vehicle is cold water, or water at a temperature below 40° C. (104° F.)

Jour. de Pharmacie, Sept. 1836.

Analysis of the Water of the Elton Lake, (Asiatic Russia). M. H. Rose.

The Elton Lake is the most important of all those that surround the Caspian sea. It is situated on the eastern shore of the Wolga, 274 versts from Saratona. Its greatest diameter from west to east is 17 versts (11 miles) and its shortest from N. to S. 13 versts (9 miles.) It is so shallow that a person may wade through it without getting more than knee deep. It furnishes two-thirds of the salt which is consumed in all Russia. The analysis of a bottle of the water of this lake, brought by M. Humbold, gave me:

Magnesia	0.1022	Chloride of Magnesium	0.1975
Soda	0.0204	Chloride of Sodium	0.0383
Potash	0.0014	Chloride of Potassium	0.0023
Chlorine	0.1697	Sulphate of Magnesia	0.0532
Sulph. Acid	0.0351		
			0.2913

Its spec. grav. is 1.27288. It contains no calcareous salts whatever, although large masses of crystallized gypsum are found on the shores of the lake. During the summer a great deal of common salt is collected on the shore, and during the winter, or even on cold nights in summer, sulphate of magnesia is deposited. The water of Lake Elton is identical with the northern mother water, which is obtained by the evaporation of the sea water in procuring common salt. Ann. des Mines.

Artificial Formation of Crystalized Pyrites. By WÖHLER.

If an intimate mixture of tritoxide of iron (for example brown hæmatite heated to redness) sulphur and sal-ammoniac be slowly heated in a glass vessel until the sal-ammoniac is completely sublimed, and the mass be allowed to cool slowly, and then water be poured on it, we shall find that heavy octahedrons and tetrahedrons, of a brass yellow will be deposited in the bottom of the vessel; and that they are identical with common pyrites. The more considerable the mass of materials the larger and better defined will be the crystals. Jour. de Pharm.

Atmospheric Electricity.

The following curious experiment has been tried with success on a mountian called Teufelsberg, near the village of Philippsthal, within the Prussian States. It became desirable to get rid of a large rock, and, in order to avoid the immense expense of the ordinary means, it was resolved to try the effect of atmospheric electricty. To this end a deep hole was made in the rock, and from it was raised a bar of iron twenty-eight feet high. At the first thunder-storm which ensued, the lightning was attracted by the iron bar, and conducted into the rock, which shattered it to pieces, and it was afterwards easily taken away.—*German paper.* Mining Journal.

Crosse's Galvanic Apparatus.

The public attention having been much excited by the unpretending statements of Mr. Crosse at the late Bristol meeting, and with the remarkable effects produced by a galvanic apparatus the most extensive of any that has ever been erected, at least by a private individual, we doubt not that the following letter, addressed to the editors of the London Mining Journal, by a gentleman so well known in science as the writer, (together with the article which immediately follows) will be acceptable to the readers of our Journal.

TO THE EDITOR OF THE MINING JOURNAL.

SIR,—Some questions having appeared in your recent numbers, concerning the construction of the galvanic apparatus of Mr. Crosse, I am happy in having it in my power, from having spent some interesting days in his house, to give your correspondents an account which I hope may prove satisfactory. I rejoice in the opportunity thus afforded me of showing, that although locally removed, I can never cease to feel a warm interest in what is passing in a county endeared to me by so many associations. Each separate combination, forming one of the members of Mr. Crosse's galvanic series, consisted of a plate of copper, containing from three to four square inches of surface, bent round so as to form a cylinder, inside of which was a similar plate of zinc; round the interior zinc cylinder a thin string was

coiled spirally, to keep its surface, throughout, separate from that of the exterior copper cylinder—these metallic cylinders, were, in about a quarter of the series, placed in glass cylindrical vessels, just large enough to contain them, and filled with water; but, in the greater number, the external copper cylinder being soldered and closed at the bottom, so as to hold water itself, the glass containing vessel was dispensed with. When this was the case, the metallic cylinder was separated from the table on which the apparatus was placed, by the intervention of a small square of common glass, a little broader than the diameter of its base; this was done to secure the insulation. These cylinders were arranged into a series, in the usual form, by copper arches passing from the copper cylinder of each combination to the zinc cylinder of its neighbour. The apparatus, when I saw it, just after the late Bristol meeting, was composed of 800 such cylinders, disposed in continuous lines, so arranged as to occupy the least room. Its effects, though excited with water only, were very powerful. I should say, equal to those ordinarily produced by about one third of the same number of galvanic combinations of equal surface, excited by acid—considerable lengths of thin wire were fused, &c. A common electrical battery of great size, containing 70 feet of coated surface, was charged in a single instant, if connected with the wires proceeding from the extremities of the galvanic series; and when successive discharges were, under these circumstances, taken from the electrical battery, the effects were most intense. After receiving three or four such discharges on the point of my pen knife, I found, on examining it with a glass, that its extremity had been completely fused. I need not dwell on the extreme importance of having constructed an apparatus capable of producing such powerful effects, when excited by water only; the excitation by acid is violent at first, but goes on rapidly decreasing, and at the end of three hours becomes almost null. If it were attempted to sustain an uniform action, by the continual affusion of fresh acid, the zinc plates would be entirely corroded in a very few days; indeed, the constant attendance necessary, and the enormous expense, would render such an attempt practically impossible. But in Mr. Crosse's apparatus, though excited by water only, we have a strength equal to very large ordinary troughs, say 300 plates, and that strength is uniform and permanent, and requires no further attendance than replenishing the water, (from the loss sustained by evaporation) once in six weeks; in this mode also, the corrosion is so slow, that the same apparatus might probably last for 20 years; much of it has already been in constant action much more than a year, and does not seem in the least impaired. The importance of imitating nature, by keeping in constant and uniform activity such powerful galvanic currents, must be obvious. Besides the series I have described, Mr. Crosse had begun to construct one of much larger dimensions; each cylinder containing a square foot in surface. Should he proceed with equal vigour we may expect some day to hear of 2000 of such cylinders; the effects must then be almost terrific. Could we, inquisitor-like, put nature to the question, by so efficient an instrument, she could hardly resist any interrogatories we might please to put to her, and all the mysteries which at present perplex us in chemistry might be expected to stand revealed. I should regard the completion of such an apparatus as quite a national object; and I feel convinced, that it is by proceeding in this line that we may best hope to see the force of electricity practically applied as a moving power, and the energy of lightning bent, like that of steam, into subserviency to the purposes of human art.

I remain, Sir, your obedient servant,

W. D. Conybeare.

Accidental production of Animal Life. By Mr. Crosse.

A communication from Mr. Stutchbury, of the Bristol Institution, has been disseminated through the public Journals, of which we give a copy. As there is no doubt of the honour and veracity of Mr. Stutchbury, the extract which this gentleman gives from a letter of Mr. Crosse, may be considered as if communicated by Mr. Crosse himself.

Sir—It may be truly said that facts recorded, faithfully detailed, and made public, are the means by which Philosophy is enabled to render her temple more durable on its foundations—every additional fact being the commencement of that which, when understood, forms an outwork of defence, rendering the interior the strong-hold and sacred depository of truth.

It was a maxim of the late John Hunter, which he was repeatedly proclaiming, that greater benefit would be conferred upon the community if professional men had the moral courage to publish detailed accounts of all their unsuccessful cases, than could be derived by the publication of those which met with a favourable termination, for then the physician would reject at once such as had failed as modes of cure, without repeating experiment after experiment, thereby saving much valuable time, and certainly sparing much needless pain to the unfortunate patient. So with facts in natural philosophy. Let experiments be recorded, and their results will enable others, either to avoid, or successfully to pursue them, so as to bring them to bear upon principles which may elucidate some great truth, the light of which would probably have never shone upon them, had they not been able to take advantage of the works of pioneers who had proceeded, perhaps, to the very threshold of the same result.

With regard to a large number of curious and (at the same time, in consequence of the principle not being understood,) astounding facts, the investigator would be doing a great injury in the cause in which he labours, should he be deterred from making them known, merely because he cannot at the same time reasonably account for the same. And upon this view of the subject, and to set at rest the vague views which are abroad, I feel it a duty due to the cause in which I am engaged, and to the philosopher with whom they have originated, at once to take the liberty of transmitting to the press, and particularly the local press, from which so many reports have emanated, an abstract of a letter I have received from Mr. Crosse, with an account of his experiments, in the language of a private communication, (not that which he would probably have chosen, had he made the communication himself,) and without further comment.

"The following is an accurate account of the experiments in which insects made their appearance:—

"*Experiment first.*—I took a dilute solution of silicate of potash, supersaturated with muriatic acid, and poured it into a quart basin, resting on a piece of mahogany; a Wedgwood funnel was placed in such a manner that a strip of flannel, wetted with the same, and acting as a siphon, conveyed the fluid, drop by drop, through the funnel upon a piece of somewhat porous Vesuvian red oxide of iron, which was thus kept constantly wetted by the solution, and across the surface of which (by means of two platina wires connected with the opposite poles of a voltaic battery, consisting of nineteen pair of five-inch plates in cells filled with water and $\frac{1}{100}$ muriatic acid,) a constant electric current was passed. This was for the purpose of procuring crystals of silex. At the end of fourteen days I observed two or three very minute specks on the surface of the stone, white, and somewhat

elevated. On the eighteenth day, fine filaments projected from each of these specks, or nipples, and the whole figure was increased in size. On the twenty-second day, each of these figures assumed a more definite form, still enlarging. On the twenty-sixth day, each assumed the form of a perfect insect, standing upright on four or five bristles which form its tail. On the twenty-eighth day, each insect moved its legs, and in a day or two afterwards detached itself from the stone and moved at will. It so happened that the apparatus was placed fronting the south, but the window opposite was covered with a blind, as I found these little animals much disturbed when a ray of light fell on them; for out of about fifty which made their appearance at once, at least forty-five took up their habitation on the shaded side of the stone. I ought to have added, that when all the fluid, or nearly so, was drawn out of the basin, it was caught in a glass bottle, placed under a glass funnel which supported the stone, and was then returned into the basin without moving the stone. The whole was placed on a light frame made for the purpose. These insects have been seen by many of my friends, and appear, when magnified, very much like cheese-mites, but from twice to eight times the size, some with six legs, others with eight. They are covered with long bristles, and those at the tail, when highly magnified, are spiny. After they have been born some time they become amphibious, and I have seen them crawl about on a dry surface.

"*Experiment second.*—I took a saturated solution of silicate of potash, and filled a small glass jar with it, into which I plunged a stout iron wire, connected with the *positive* pole of a battery of twenty pair of cylinders, filled with water alone, and immersed in the same a small coil of silver wire, connected with the *negative* pole of the same battery. After some week's action, gelatinous silex surrounded the iron wire, and, after a longer period, the same substance filled up the coil of silver wire at the other pole, but in much less quantity. In the course of time one of these insects appeared in the silex at the negative pole, and there are at the present time not less than three well-formed precisely similar insects at the negative, and twelve at the positive pole, in all fifteen. Each of them is deeply embedded in the gelatinous silex, the bristles of its tail alone projecting, and the average of them are from half to three quarters of an inch below the surface of the fluid.

"In this last experiment we have neither *acid*, nor *wood*, nor *flannel*, nor *volcanic iron-stone*. I will not say whether they would have been called to life without the electric agency or not. *I offer no opinion, but have merely stated certain facts.*"

In addition to this, on Friday, the 10th ult., Mr. Crosse transmitted to Mr. Owen, Hunterian Professor, College of Surgeons, London, a copy (perhaps the original,) of the above, in his own hand-writing, with several specimens of the insects themselves, so enclosed in Canada balsam and between plates of glass and talc, as to be easily submitted to examination in the microscope. By the kindness of this gentleman, Mr. Clift, conservator of the museum, in the same establishment, produced them at the *Conversazione* of the Royal Institution on Friday, the 17th, when they were most satisfactorily visible in the microscope. By an extension of the same courtesy on the part of Mr. Owen, we have been permitted to draw and engrave two of the groups of these mysterious visiters, in order to gratify the prevailing intense desire for accurate information upon the subject.

The Insects magnified.

Cheese Mite, magnified to the same degree.

The insects above delineated are some of those collected and sent to London by Mr. Crosse. We have placed an ordinary cheese-mite near them, drawn to the same scale, in order to show the relative size, and the similarity of appearance. Like the mite, the new insects have fine hairs scantily distributed on the body, but these became invisible on the immersion of the insect in the balsam. Their varied positions, the arrangement of their legs, &c., are owing to their accidental suspension in the balsam, and the subsequent pressure of the plate of talc upon them. Mag. Pop. Sci.

On the Solidification of Silver in Fusion.

The result of the Experiments of M. Fournet, as applied to his New Theory on Volcanic Formation.

M. Fournet has recently placed the theory of volcanos, in altogether a new point of view. In the following abstract he applies to the illustration of this subject, the phenomena presented by the solidification of silver held in fusion in an atmosphere abounding with oxygen.

By the experiments of Messrs. Lucas and Guy Lussac, it is found that silver in a state of fusion, and exposed to the atmosphere, absorbs oxygen, and on becoming solid, gives it out again. The quantity of this gas thus absorbed may amount to twenty-two times the volume of the mass of silver; and to its evolution is to be ascribed the apparent ebullition observed by assayers. Hitherto no attention has been paid to the remarkable circumstances attending this process, when the experiment is conducted on a somewhat larger scale.

Having had occasion frequently to refine, in small reverberatory furnaces, silver bars of forty to fifty pounds weight, I can warrant the following as correct results, when the silver is sufficiently fine, and the cooling gradual. The solidification commences at the edges and advances towards the centre, and the silver when passing from a fluid to a solid state, experiences a very slight agitation or ebullition, and then becomes motionless. Matters remain thus for a short time, to all appearances perfectly tranquil, when suddenly a part of the surface becomes irregularly perturbed, fissures appear in one or several lines, from which flow, in different directions, streams of very fluid silver, which increase the original agitation. The first stage does not yet clearly manifest the presence of gas, and seems to arise from some intestine motion of particles in their tendency to group on entering the process of crystalization, and thus causing the rupture of the envelope, or external crust, and the ejection of some liquid portions.

After remaining some time tranquil, the metal presents a fresh appearance, precisely analogous to volcanic phenomena. As the crystalization continues, the oxygen gas is given out with violence at one or more points, carrying with it melted silver from the interior of the surface, producing a series of cones, generally surmounted by a small crater, vomiting out streams of the metal, which may be seen boiling violently within them.

These cones gradually increase in height by the accumulation of metal thrown up, and that which becomes consolidated on their sloping sides. The thin crust of metal on which they rest consequently experiences violent impulses, being alternately raised and depressed by such violent agitation, that were it not for the tenacity and elasticity of the metal, there would evidently arise dislocations, fissures, and other analogous accidents. At length several of the craters permanently close, whilst others continue to allow the gas a passage. The more difficult this is, the more the craters become elevated, and the more their funnels contract by the adhesion or coagulation of a portion of the metal. The projection of globules of silver now becomes more violent; the latter being carried to great distances, even beyond the furnace, and accompanied by a series of explosions, repeated at short intervals. It is generally the last of these little volcanos that attains the greatest altitude, and exhibits the foregoing phenomena with the greatest energy. It is moreover observable, that these cones do not all arise at the same time, some having spent their force, when others commence forming at other points. Some reach the height of an inch, forming bases of two or three inches in diameter, and the time occupied by this exhibition is at least from half to three quarters of an hour.

During the formation of these cones, by the evolution of gas, portions of silver are shot forth, which assume on induration, a form somewhat cylindrical, and often very fantastic, notwithstanding the incompatibility which appears to exist, between the fluidity of the silver and these elongated figures. Their appearance is momentary, and without any symptoms of gas, although it is impossible to decide whether they may not arise from its influence; they seem, in fact, to resemble the phenomena of the first volcanic period.

These ebulitions, which continue until the metal is completely solidified appear to me identical with geological phenomena: not a single feature of resemblance is wanting, the rising and falling of the surface, perturbation of the soil, fractures, fissures, volcanos with crater, evolution of gas, and ejection of streams of lava, all these present a remarkable similarity, the difference consisting only in dimensions.

From the above observations, we may deduce the following comparative results.

The mass of the globe, as it has been demonstrated by the labour of modern geologists beyond a doubt, was at first in a fluid state, like the silver in question. In consequence of this igneous fluidity, favoured besides by the atmospheric pressure, the earth has absorbed the gases surrounding it. Those possessing powerful affinities, such as oxygen, &c. have combined directly with a portion of the metals and metalloids, and remain united with them; but such as possess only weak affinities, have remained for a longer or shorter period simply condensed, being then emitted at various intervals, and at different points, and will continue to be so given out until the whole mass in which they are contained in solution shall be solidified, inthe same manner as the air combined in water becomes disengaged from it during crystalization or freezing.

In the process above described, the oxygen exhibits too little affinity to remain united with the metal. In the corresponding phenomenon on the terrestial globe, it is carbonic acid and aqueous vapours, which are the most active agents; and consequently we find them abounding in all volcanic regions, whether the volcanos be in activity or not.

Among the gases evolved, azote but rarely occurs. Does this proceed from its being overpowered by too great a surrounding mass? Has it more generally formed combinations producing the results observed in mineral waters, &c.?

Finally, in these phenomena, has the terrestial mass in fusion, shown a preference for other gases, to the exclusion of nitrogen, as the melted silver in the furnace exhibits no tendency to unite with carbonic acid, or other gases resulting from combustion? I leave geologists to decide these questions.

On the other hand, nitrogen may be disengaged more rapidly than other gases, as copper gives out sulphuric gas before its solidification, and then undergoes a violent ebullition.

The enormous quantity of carbonic acid continually arising in volcanic districts, either with or without mineral waters, might be adduced as evidence of the ancient state of the atmosphere, so rich in this gas, that M. Brongniart attributes to it the vigorous vegetation of the primordial ages; and the circumstances attending the refining of silver, all denote an atmosphere abounding in oxygen.—*Traité de Géognosie, par M. de Voisins, tome iii.*

Mining Review.

On the Symmetrizing Power of the Eye. By the Rev. J. G. Macivar, A. M.

Let the surface of a glass mirror be sprinkled over with some powder, as, for instance, with flower from a dredging-box. This done, on looking perpendicularly down upon the reflecting surface, at the distance of distinct vision from it (unless the eye be too long-sighted,) the powder will appear, not irregularly scattered, as it really is, but symmetrically distributed in two systems of beautiful radiations, having the pupils of the eyes for their centres.

The phænomenon is sufficiently remarkable to strike even those who are not otherwise curious in such matters. It may be observed, however, that as every eye cannot catch it at once, it is better to commence by using one eye only, as this gives only one system of radiations, which, being more simple, is more easily observed. If this phænomenon has not been already attended to (and I do not recollect to have seen it noticed anywhere,) it is, I think, well worthy of investigation. Some facts are, indeed, immediately obvious respecting it. Thus, as to the region in which the physical part of the phænomenon takes place, it plainly appears that it is not either the humours or retina, as is generally supposed in reference to other phænomena of the same order, but a more deeply seated part of the apparatus of vision. For if it were any of these anterior parts, or even the retina itself, the centre of the radiant system would certainly change its place when the eye was made to wander over the mirror. In point of fact, however, that centre does not change place except when the whole head is moved, in which case it does so proportionally.

I ascribe the phænomena to a peculiar mode of action in the nervous part of the apparatus of vision, proper to it as an elastic tissue, in virtue of which

it tends, like the tissues and media experimented on by Chladni, Savar, Faraday, and others, and doubtless all elastic tissues and media, to distribute all motions impressed upon it in symmetrical systems; a view of the matter having very interesting bearings upon the principles of taste,—during the investigation of which it was that this experiment first occurred to me,—and one calculated to explain several seemingly unaccountable phænomena as to the distribution of sensibility in the retina.

Johnfield by Dundee, Oct. 14. L. & E. Phil. Mag. Jour. Sci.

Bibliographical Notice.

Methods of Location; or modes of Describing and Adjusting Railway Curves and Tangents, as practised by the Engineers of Pennsylvania, revised and extended by Samuel W. Mifflin, Civil Engineer. Philadelphia, Edward C. Biddle, 23 Minor street, 1837. 12mo. pp. 41.

We have given this little work a careful perusal, and think that although in some respects imperfect, it is not destitute of professional merit; but supposing the Engineer to be sufficiently versed in the principles of Geometry, it furnishes the information which is promised in its title page. The chief fault which we have to find is some obscurity in the explanations, and particularly in the enunciation of the 8th, 10th, and 11th propositions, in each of which it should be mentioned that the radius of the curve last referred to is given. To its praise we would add on the other hand, that the propositions from the 6th to the 13th inclusive, contain some of the most beautiful practical applications of geometry; most of which we have never seen in any other treatise; and all of which are of great importance to the Railroad Engineer.

All these propositions depend on the fundamental problem,—to describe a circle of any given curvature, proceeding from a given point in a given straight line, and tangent to that line. We regret, therefore, that this proposition is not more fully explained, and do not see how it can be resolved without the use of the table of chords or some equivalent table; although the author implies the contrary, when he says "there is nothing in the following pages which may not be remembered by an assistant after a short practice, *and executed in the field even if the book be left at home.*" Believing as we do, the table of chords to be an essential *vade mecum*, we would have wished to see its applications more fully illustrated. It will of course be seen that the chord of any given number of degrees, to a radius of unity, is found from Mr. Mifflin's Table by adding together the degrees on the top and in the margin and seeking the chord under the former and on a line with the latter, or at the angular meeting of the line and column.

As reference is made to the Transit Instrument, invented and manufactured by W. J. Young, 9 Dock street, Philadelphia, it may be interesting to add that this instrument is not intended for leveling, although it might be thus used by attaching an additional spirit level; nor is it intended for taking vertical angles, as may be done by the Theodolite. It consists of a ten inch telescope, revolving in a vertical circle on a horizontal axis, which latter rests on supports that turn with a horizontal circle, graduated to minutes and attached to an interior vernier, as also with a compass needle. Its uses therefore are to run lines either continuous or making any required angle, and to take bearings or measure horizontal angles. For these espe-

cial purposes it serves as well as the theodolite, is used in the same manner, and is much more portable, simpler, and less likely to get out of repair. It is also much cheaper; its cost being $140 or $150. While on this subject we would take the liberty to suggest the name *Nivellite*, for the simple Levelling Instrument without horizontal or vertical circle; the term being borrowed from the French *Niveau*, a level, and intelligible when once heard, by its derivation. R. P.

Mechanics' Register.

Purification of Coal Gas.

Mr. H. Phillips, superintending engineer of the Exeter Gas Works, has discovered the means of arresting the volatile alkali, to which, from its known corrosive property, when in contact with copper or brass, is to be attributed the destruction of cocks, fittings, and metres; and as azote (one of the constituents of ammonia) is highly injurious to respiration, that peculiarly pungent and obnoxious quality of the air in rooms in which coal-gas is burnt for a long portion of the night is probably augmented, if not produced by it, from the circumstance of the ammonia not being previously separated; azote is alike injurious to combustion; by employing two burners of the same size, and supplying one with gas from which the ammonia has been removed, and the other with gas from which ammonia has not been removed, the superiority of the light produced by the one over that produced by the other will be clearly apparent. Mr. Phillips has taken out a patent for his discovery.—*Worcester Journal.* Mining Journal.

Heating effects of the Gas of the City of London, on the Atmosphere. By W. H. White, Esq.

During the severe frost between Dec. 19, and 27, 1835, I observed the streets in the city to become very dirty after the evening closed in; so that I more than once was led to the conclusion that a rapid thaw was taking place; but when I came near to my house (3 miles south of London Bridge,) I found the roads quite hard, and the trees still covered with their icy crystals: this led me to the consideration that the difference of temperature in the city was owing to the heat given out by the gas. It was, however, not very difficult to make the experiment with the thermometer; in doing which, I found that the temperature during the day, in the city, was 3° Fahrenheit higher than at my house; and that, after the gas in the city had been lighted four or five hours, the temperature increased full 3°: thus making the difference of 6°, and sometimes as much as 7°, in the space of three miles.

This notice, though unimportant in itself, if you think it worthy of a place in your Magazine, may probably lead to further experiments, and to other useful applications of the gas than merely the light from its brilliant flames.

Old Kent Road, Jan. 1, 1836. Mag. Nat. History

Mode of ascertaining the Proportion of Carbon in Cast-Iron.

Berzelius, in a letter communicated by M. Pelouze, to the *Société Philo-*

mathique of Paris, announces that he has discovered a very short process of analysing the various kinds of cast-iron, and of ascertaining the exact proportions of carbon that they contain.

His mode consists in boiling the iron in a bichlorate of copper, slightly acidulated with hydrochloric acid; then to boil the residue with carbonate of soda. The weight of this second residue, washed and dried, gives that of the carbon. This process has been repeated by M. Gaultier de Claubry, who found that to succeed it was necessary that the chlorate should be strongly acidulated before adding the iron in filings, otherwise copper is precipitated; but with this precaution, the analysis may be completely accomplished in ten or twelve minutes. Mag. Pop. Science.

Russian Railroad.

A railroad is now forming, or rather nearly completed, between St. Petersburgh and Zarskojeselo. Though it has been represented to be under the especial protection of the Imperial Government of Russia, it is the work of a company of shareholders, who received from the Emperor an ordinance, dated March 21, granting various privileges. Some description of this Russian railroad may not prove uninteresting. The line commences nearly in the centre of St. Petersburgh, continues in almost a straight line, and with a medium rise of 1 in 1028, for about eighteen miles, and terminates within the great park of Pawlowsk. The rails, locomotive carriages, and other railway machinery, were contracted for in this country by the Chevalier von Genstner, the engineer, and are to be admitted into Russia duty free. The locomotives will be, it seems, remarkably powerful, the width of the track being laid down at six feet, instead of four feet eight inches and a half. It is declared that Stephenson's engine, on trial, was propelled 65 miles and a half, and Hackworth's at the rate of 72 miles, per hour. The engines are to be provided with apparatus in advance of the engine for clearing away the frozen sleet and snow from the rails; and each is to carry a trumpet instrument that will perform by mechanism flourishes and marches with a power equal to that of a brass band! The work was commenced in April last, and is to be completed this October. It is proposed that the whole line should be lighted with gas. Mining Journal.

Steam Carriages on Common Roads.

Mr. Walter Hancock, accompanied by a party of gentlemen interested in mechanical inventions, started on Friday the 21st inst., in "the Automaton," from the City-road to Epping. This line of road was selected by Mr. Hancock on account of its being, for the distance, the most hilly and uneven out of the metropolis. On arriving at Woodford, Mr. Hancock stopped the carriage, where he procured a fresh supply of water. After remaining for nearly a quarter of an hour, he again started at a rapid pace, and having ascended Buckhurst-hill at the rate of seven and a half miles an hour, entered Epping amidst the loud cheers of some thousands who were collected in the town, it being market-day. The party returned to town; and the whole journey, notwithstanding the disadvantages before-mentioned, was performed on the average of eleven and a half miles an hour. Ibid.

Coal Mines. Singular Circumstance.

The following singular circumstance relating to coal mines, which hap-

pened a few years ago in Parr (about fourteen miles from Liverpool,) where there are several extensive collieries, will tend to show the immense value of coal mines which lie under a small superficial extent of land. An elderly widow lady sold property in Parr, consisting of a house and about thirty acres of land, to a gentleman (who purchased it for his own residence) for 3000*l.* The old lady thought there must be coal under the land, as there was so much in the neighbourhood, but it was the decided opinion of coal-proprietors, and others conversant with coal-mines, that there were not any coals in the property, or if there were, that they could not be got from the working of any adjacent colliery, on account of part of the land constituting what is called a fault, viz. an intervention of stone and earth, which sometimes happens (perpendicular) so as to separate delfs of coal from each other, and consequently they were of no value. The seller of the property, however, insisted that the coals should be reserved, unless the purchaser would give her 100*l.* for them. This he refused doing, and the coals were excepted from his purchase. The old lady died soon after, bequeathing the coal-mines among the children of a deceased sister (seven in number,) who were all labourers, and the residue of her property, worth about three hundred pounds, to the children of another sister. The bequest of the coal-mines was considered a mere nominal thing, and the dissensions in the two families were great on account of it. The coal legatees brooded for a length of time over their disappointment in not sharing their aunt's property with their cousins, but at length they contrived to induce some persons, who were supposed to have more money than wit, to undertake the expense of boring on the land (an expensive undertaking,) to ascertain whether there were coals or not. The boring continued for a length of time, to the great amusement of persons connected with the collieries; but at last, to their great astonishment, the chagrin of the purchaser, and the unbounded delight of the legatees, two delfs of the best coal in Lancashire were discovered extending nearly the whole breadth of the land, and could be easily worked. These coals were immediately purchased by the proprietors of a neighbouring colliery for 20,000*l.* On subsequent borings, three lower delfs were found, which the same parties purchased for 15,000*l.*—*Liverpool paper.*

Ibid.

Beet Root Sugar.

The beet-root has become an object of cultivation at Wandsworth, and other places in the vicinity of the metropolis. At Thames-Bank, Chelsea, a sugar refinery is now erecting. After the juice of the beet-root has undergone the process of decolorisation, the sugar will be produced from it by evaporation. As the different varieties of beet are indigenous to the northern parts of Europe, agriculturists are alive to the profits of such a produce in England, which is now a source of great advantage in France.

Should government not interfere, there is no doubt but sugar refineries will become general throughout the agricultural districts of Britain, for purifying sugar for domestic purposes.

In France, a coarse brown paper is manufactured from the refuse of the beet-root, after the saccharine juice has been extracted; and it is intended also to establish a paper manufactory at the refinery now erecting at Thames-Bank, Chelsea. A sugar refinery has lately been erected at Belfast, in the vicinity of which place upwards 200 acres of land have been planted with beet-root.—*W. H. W. Oct.* 17, 1836.

Mag. Nat. Hist.

Incendiaries discovered by Bloodhounds.

The old method of tracing perpetrators of any crime was, a short time since, revived with great success in Oxfordshire. The duke of Marlborough has, in addition to the famous Blenheim spaniel, retained unimpaired the breed of the old English bloodhound. The Duke's steward, who has the care of these noble animals, had recourse to this plan at that destructive fire (well known in the neighbourhood) at Mr. G. Raingley's, of Woodstock, one of the Duke's tenants. The steward was one of the first on the spot, and observed some fresh footsteps: he therefore marked their direction, and summoned his conductor. The hound was no sooner put on the footstep than he opened his deep-toned note, and traced with wonderful exactness every winding attempt to delude his eager pursuit, until he reached a previously notorious cottage. The door was opened; but then appeared the failure, for no man was found: however, the insatiable pursuer was not to be thus deluded; for, rushing out in the direction of the fire, he became more anxious at every step, until he seized one of a group going to assist (and, as was afterwards proved, the one most lavish in abuse of the incendiary,) to his no small astonishment. The man was thunderstruck at his unexpected discovery, and soon confessed that he was the actual perpetrator of the diabolical act." (*The Bury and Norwich Post and East Anglian, Feb.* 12, 1834.) Ibid.

Biot and Newton.

A memoir on astronomical refraction was lately read at the *Académie des Sciences*, in which the distinguished author, M. Biot, successfully proved that there was one honour, not hitherto supposed to belong to him, yet due to the illustrious Newton, namely, that of having discovered the theory of astronomical refraction. M. Biot having perused with close attention the letters of Newton to Flamsteed, published in the past year by Mr. Baily, found in them the complete series of ideas that Newton had followed out in order to calculate the table of refractions which was subsequently published in his name by Halley, in the *Philosophical Transactions*, 1721, without the slightest reference to the means employed to form it. It is thus certain that Newton was in possession of differential expressions of astronomical refractions similar to those used at the present day, and that he had deduced from them, theoretically, his table for the case of an uniform temperature. M. Biot, in order to exhibit them in a simpler form, went through the calculations of Newton, and by them arrived at the same numerical results as those which are furnished by the methods now in use.

"Thus," remarked M. Biot, "we have yet to add to the vast number of other discoveries made by this great man that of the theory of astronomical refraction. If we reflect that he was obliged, as his correspondence shows, to discover for himself, one after another, all the physical bases, and all the meteorological elements, of this theory, and that at a time when no person but himself suspected that the indications of the barometer and the thermometer had the slightest relation with these refractions, and that he at length attained, approximately it is true, but by a method direct, and due to himself alone, the same numerical values which the mathematicians of the following age regarded as one of the grandest results of the improved integral calculus, we shall, without doubt, admit that such an acquisition was one of the finest works of his immense genius, and one which, beyond all

others, best demonstrates the sagacity with which he seized all the constituent elements of the complicated phenomena which he submitted to investigation."

That this act of justice to the departed English mathematician should have been neglected by his scientific countrymen is, to say the least, remarkable;—that it should have been rendered by a Frenchman, and by a philosopher so eminently qualified to appreciate the discovery, and that he should have deduced it from a correspondence supposed, by some persons, slightly to tarnish the lustre of a splendid reputation, is one of the most striking and gratifying events in the progress of modern science.

Is there no academy of either nation (for both countries are now equally interested in the commemoration of this glorious event,) patriotic enough to offer the following subject for a prize in painting? BIOT *announcing to the* Académie des Sciences, *a century after the death of* NEWTON, *the discovery by that illustrious Englishman of the theory of Astronomical Refraction.* Mag. Pop. Sci.

Recent Meeting of the German Naturalists, &c.

The annual meeting of the naturalists and medical men of Germany, commenced at Jena, in the Duchy of Saxe-Weimar, on the 20th ult. and terminated on the 26th; Dr. Keiser, President. The number of members was large. From countries foreign to Germany, there were more from Great Britain than any other. France did not appear to have had one. Among the British visiters, were Professors Daubeny (Oxford,) (distinguished so recently for the effective discharge of his duties as one of the secretaries of the British Association at Bristol)—Graham (Glasgow,) and —Kane (Dublin.) The Grand Duke of Saxe-Weimar and his court were present, and paid the most marked respect to the objects and members of the Association. The Duke of Saxe-Altenburg founded a premium in Natural Philosophy, for the students of the University of Jena, as a token of the interest he felt in the Association. The meeting for 1837 is to be held at Prague. It was stated that the number of members at Bonn in 1835, was about five hundred. Ibid.

Stage Coaches

Were first introduced into Scotland in 1678. On the 6th of August, in that year, the magistrates of Glasgow contracted with William Hume, of Edinburgh, that he should run a coach between Edinburgh and Glasgow,—forty-two miles. Hume engaged, with all diligence, to run a coach with six able horses, that should "leave Edinburgh every Monday morning, and return (God willing) every Saturday night." Mec. Mag.

Paddle-Wheel Experiment.

A recent experiment has proved that the supply of water to the paddle-wheels of steam-vessels does not come from the surface of the water, or from the sides of the space through which the wheel moves at each evolution of the water, but from beneath. It was proved as follows:—A steam-vessel was moored at deep water, which was strewed (it being calm weather,) with sawdust; the engine was then put in motion, and it was observed that the sawdust all around and every where, except immediately behind the paddle-wheels, remained undisturbed.—Times. Ibid.

Sheffield.

The entire consumption of Coal in this town amounts annually to 515,000 tons, the whole of which is taken from collieries in the immediate vicinity of the town. Min. Jour.

A Sale of Dogs

Belonging to the late Duke of Gordon took place on the 7th of July last. Forty dogs and twenty-five whelps, brought 1148*l* 5*s* 6*d*. The highest prices were, Vaultress, a red bitch, 53*l* 11*s*; Young Regent, black and white tan, 75*l* 12*s*; and Crop, a black and white bitch, 63*l*,—all bought by Lord Chesterfield.—Saturn, a black dog, by Lord Douglass 58*l* 16*s*;—Bess, a liver and white bitch, by Lord Abercom 48*l* 6*s*; Diver, a liver coloured dog, Mr. Martyn 44*l* 2*s*; Vivid, a black bitch, by Lord Lisburn 38*l* 17*s*; &c. A black fast trotting mare brought 194*l* 5*s*. Farm. Mag.

Indian Ink.

The Chinese, or, as it is miscalled, Indian ink, has been erroneously supposed to consist of a species of *sepia* or scuttle-fish. It is, however, all manufactured from lamp-black and gluten, with the addition of a little musk to give it a more agreeable odour. Père Contacin gave the following as a process for making ink:—A number of lighted wicks are put into a vessel full of oil. Over this is hung a dome or funnel-shaped cover of iron, at such a distance as to receive the smoke. Being well coated with lamp-black, this is brushed off and collected upon paper. It is then well mixed in a mortar, with a solution of gum or gluten, and then reduced to the consistence of paste, it is put into little moulds, where it receives those shapes and impressions with which it comes to this country. It is occasionally manufactured in a great variety of forms and sizes, and stamped with ornamental devices, either plain or in gold and various colours.—*The Chinese, by J. F. Davies.* Min Jour.

Railway Travelling.

On the morning after the fancy-ball, a train, loaded with guests, left the railway at half-past five o'clock, and was drawn by the Firefly, locomotive engine, to Manchester, in fifty minutes, being ten minutes under the hour. After arriving at Manchester she immediately returned with a load of goods, and arrived at Liverpool at eight o'clock, being only two hours and a half in performing the two trips. Ibid.

German Railroad.

It is a remarkable fact, that in the formation of the railway between Prague and Pilsen, the individuals employed were chiefly females, each of whose wages amounted to 6d. a day. There were upwards of 2000 regularly engaged as labourers, in forming the embankments, excavating the soil, &c. During the two first years the engineer was able, in the course of 40 English miles, to cut no less than 696,465 cubic yards, and to construct 807,844 cubic yards of embankment, besides laying the way with malleable rails. He erected during these two years 73 bridges from three to eighteen yards each, with 133 culverts; and he also made 236 wagons. And all this at an expense of about 75,200*l*.—*Strang's Germany.* Ibid.

LUNAR OCULATIONS FOR MAY, 1837.

Day.	H'r.	Min.			N.	V.
9	11	28	Im.	*c* Gem. 6.	68	116

Meteorological Observations for January, 1836.

Moon ☽ Days.	Therm. Sun rise.	Therm. 2 P.M.	Barometer. Sun rise.	Barometer. 2 P.M.	Wind. Direction.	Force.	Water fallen in rain.	State of the weather, and Remarks.
	☉	☾	⊗					
			Inches	Inches			Inches.	
1	27°	35°	29.70	29.50	S.	Calm.		Cloudy—do.—snow.
2	5	8	50	45	W.	Blustering.		Clear—lightly cloudy.
3	4	13	30	34	W.	d.o.		Squally—lightly cloudy.
4	13	22	30	3.	W.	Moderate.		Clear—cloudy.
5	19	30	35	3.	W.	do.		Partially cloudy—do. do.
6	21	36	50	50	W.	Brisk.		Clear—do
7	25	30	25	20	W.	do.		Clear—lightly cloudy.
8	26	32	20	54	W.	do.		Clear—lightly cloudy.
9	24	36	60	60	W.	Moderate.		Partially cloudy—clear.
10	26	36	60	60	E.W.	do.		Cloudy—cloudy.
11	26	34	80	81	W.	do.		Clear do.
12	27	34	30.00	30.00	W.	do.		Clear—partially cloudy,
13	19	21	29.90	29.85	NW.	do.	.21	Cloudy—do—snow in night.
14	11	22	84	83	W.NW.	do.		Cloudy—do.
15	4	27	60	74	W.	do.		Clear—do.
16	25	31	64	70	W.	do.		Partially cloudy—do—do.
17	29	36	70	75	W.NW.	Calm.		Partially cloudy—cloudy.
18	36	36	75	75	N.	do.		Cloudy—do.
19	33	39	80	72	E.	do.		Cloudy—do.
20	30	39	40	60	F.	Blustering.	1.40	Sleet—rain.
21	25	35	29.85	50	E.W.	do.		Snow—partially cloudy.
22	23	26	29.70	84	W.	Calm.		Clear do.
23	15	26	84	84	W.SW.	do.		Cloudy do.
24	22	32	90	84	W.	Moderate.		Cloudy—cloudy—remarkable
25	21	29	30.00	30.00	NW.	Calm.		Cloudy—lightly cloudy. [Aurora
26	13	28	00	00	W.SW.	Moderate.	.18	Clear—cloudy—snow.
27	12	34	00	10	W.	Brisk.		Partially cloudy—do—do.
28	13	37	29.63	29.70	W.SE.	Moderate.		Clear—lightly cloudy.
29	13	39	30.10	30.00	NE.	do.	.14	Rain—drizzle.
30	14	40	29.74	39.70	W.	do.		Cloudy—clear.
31	35	44	39.67	65			1.93	
Mean	21.48	30.03	29.67	29.67				

Thermometer.			Barometer.	
Maximum height during the month		44. on 31st.	30.10 on	13th & 29th.
Minimum	do.	4. on 3d.	28.85 on	22d.
Mean	do.	28.75.	29.67.	